ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5523

Catch-fluctuation patterns of Todarodes pacificus (Steenstrup) in northern Japanese coastal waters of the Pacific Ocean

Y. Ogawa and T. Sasaki

Original title: Honpo Hokubu Taiheiyo Engan Surumeika Gyokyo no Hendo Yoshiki

In: Tohokuku Suisan Kenkyusho Kenkyu Hokoku/Bull. Tohoku Reg. Fish. Res. Lab. 50: p. 1-24, 1988.

Original language: Japanese

Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1991

90 typescript pages

Secretary of State / Secrétariat d'État

91-04124/

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU BUREAU DES TRADUCTIONS

LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

Translated from - Traduction de	Into - En
Japanese	English

Author - Auteur

Yoshihiko OGAWA and Tomoko SASAKI

Title in English or French - Titre anglais ou français

Catch-Fluctuation Patterns of Todarodes pacificus (STEENSTRUP) in Northern Japanese Coastal Waters of the Pacific Ocean

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)

Honpo Hokubu Taiheiyo Engan Surumeika Gyokyo no Hendo Yoshiki

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.

Tohokuku Suisan Kenkyusho Kenkyu Hokoku

Reference in English or French - Référence en anglais ou français

Bulletin of the Tohoku Regional Fisheries Research Laboratory

Publisher - Éditeur	DATE OF PUBLICATION / DATE DE PUBLICATION			Page Numbers in original / Numéros des pages dans l'original
	Year / Année	Volume	Issue No. / Numéro	pp. 1-24
Place of Publication / Lieu de publication				Number of typed pages / Nombre de pages dactylographiées
Japan	1988		50	88

Requesting Department / Ministère-Client: DFO

Branch or Division / Direction ou Division: NW Atlantic Fisheries Centre, P.O. Box 5667, ~~St. John's, Newfoundland A1C 5X1~~

Person requesting / Demandé par: Earl Dawe

Your Number / Votre dossier nº:

Date of Request / Date de la demande: September 10, 1990

Translation Bureau No. / Notre dossier nº: 3850513

Translator (Initials) / Traducteur (Initiales): JM / PS

JAN 14 1991

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISÉE
Information seulement

Canada

SEC 5-111 (84-10)

Department of the Secretary of State of Canada | Secrétariat d'État du Canada

TRANSLATION LETTERHEAD - PAPIER À EN-TETE

MULTILINGUAL TRANSLATION DIRECTORATE
TRANSLATION BUREAU

DIRECTION DE LA TRADUCTION MULTILINGUE
BUREAU DES TRADUCTIONS

Originator File No. - Référence du demandeur	Department - Ministère	Division/Branch - Division/Direction	City - Ville
G-500	DFO	Scientific Pubs	Ottawa
Translation Request No. - N° de la demande de traduction	**Language - Langue**	**Translator (Initials) - Traducteur (initiales)**	
3850513	Japanese	JM / PS	JAN 14 1991

HONPO HOKUBU TAIHEIYO ENGAN SURUMEIKA GYOKYO NO HENDO YOSHIKI p. 1
(CATCH-FLUCTUATION PATTERNS OF Todarodes pacificus (STEENSTRUP)
IN NORTHERN JAPANESE COASTAL WATERS OF THE PACIFIC OCEAN)

Yoshihiko OGAWA and Tomoko SASAKI

Tohokuku Suisan Kenkyusho Kenkyu Hokoku (Bulletin of the Tohoku Regional Fisheries Research Laboratory), No. 50, 1988. pp. 1-24

Abstract The annual catch of squid *Todarodes pacificus* in the Pacific waters along the northeastern Japan drastically declined from 1969 through 1972. There are at least two possible causes of this decline. One is a decrease of *Engraulis japonica*, an essential prey for the squid, which is accompanied by a long-term hydrographic change from a high-temperature to a low-temperature era. The other is an increase in numbers of *Thunnus thynnus*, a major squid-predator, in the East China Sea where the major winter group of the squid spawns. The bluefin-tuna increase seems to be closely related with a replacement of a dominant species from *Engraulis japonica* to *Sardinops melanosticta* in the coastal pelagic-fish community. Since the 1969-1972 decline, catches of *Todarodes pacificus* shows four favorable peaks in 1975, 1980, 1981 and 1984. These peak catches are comprised of a local spring group, while most of the catches before 1973 consisted of the winter group. The peak catches were also accompanied by abundant occurrences of prey-species such as *Engraulis japonica*, *Ammodytes personatus* and *Euphausia pacifica* or by propitious hydrographic events related to the First Oyashio Intrusion.

Keywords Oyashio, pelagic-fish community, predator, prey, squid

1. Introduction

The angling fishery for squid, Todarodes pacificus, is one of the important coastal fisheries which has been in operation from the olden times in various districts centering around the Sanriku area of the northern Japanese coastal waters of the Pacific Ocean (Iwate Prefecture 1984, Iwate Prefectural Fisheries Experimental Station 1960, Tohoku Historical Archives 1984 a, b). The annual catch of

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

SEC 5 - 159 (90-01)

Todarodes pacificus in Japanese waters had maintained the high level of 300,000-600,000 tons, however, with a fair amount of fluctuation, over a period of twenty years from the early 1950's to the latter half of the 1960's. However, thereafter it suddenly declined and now remains at a low level (ARAYA 1985, SHINGU, MURATA and ISHII 1983, YASUI 1974, 1975). Incidentally the annual catch of Todarodes pacificus in 1985 was only about 133,000 tons.

The annual catch of Todarodes pacificus in the northern Japanese coastal waters of the Pacific Ocean has also followed basically the same fluctuation tendency (ARAYA 1985, YASUI 1975). In particular, the annual catch which had maintained a high level of several 100,000 tons in the 1960's had dropped to a poor catch of 30,000 tons in 1973 and thereafter has stayed at a low level (SASAKI 1987). This is understood as a phenomenon caused by a decline in the resource level of the so called "winter group" which spawns in winter in the East China Sea and which migrates largely northwards and becomes the major catch in various northern coastal districts (ARAYA 1967, 1974, 1985, ARAYA 1976, DOI and KAWAKAMI 1979, MURATA and ARAYA 1977, OKUTANI 1983, OKUTANI and WATANABE 1983, SHIBATA 1984, YASUI and others 1972a, YASUI 1974, 1975). However, in the northern coastal regions of the Pacific Ocean around Sanriku, the dependency of small-scale fishermen on the squid angling fishery is still great. Therefore they are very much interested in the catch

of Todarodes pacificus and their demand for catch forecasts is strong.

With the decline of the resource level of the winter group, the annual catch has been at a low level since 1973. However, the consolidation of the following basic knowledge necessary for catch forecasting is still insufficient: (1) catch-fluctuation patterns of Todarodes pacificus in northern Japanese coastal districts of the Pacific Ocean, (2) the difference in patterns compared with those in the good catch era, (3) the cause of the present fluctuation patterns and the difference from those in the good catch era in relation to the environmental changes and (4) the cause of the decline in the winter group resource of Todarodes pacificus.

The authors would like to report therefore the results of their studies. (1) Their primary objective with regard to the following activities was to clarify the points mentioned above. (2) Based mainly on the statistical data of catches, they analyzed the time and space fluctuation patterns of catches of Todarodes pacificus in the northern Japanese coastal waters of the Pacific Ocean. (3) They studied the characteristics of the catches in the period of low resource level. (4) They discussed the changes in the structure of catch groups accompanied by the resource fluctuations. (5) They analyzed the resource level and the main factors of catch fluctuations from both biological and hydrographic sides. (6) They elucidated the multiplicity

p. 2

Fig. 1 A rough sketch of hydrographic conditions in the study area and locations of fishing ground for *Todarodes pacificus*. Areas shaded with oblique lines and dots indicate fishing grounds for angling boats and trawlers, respectively. Solid circles show locations of major fishing ports where *Todarodes pacificus* is landed.

of environmental effects on organisms and its importance. ⑦ They studied the possibility of catch forecasts of Todarodes pacificus.

2. Data and methods

The locations of fishing grounds for Todarodes pacificus, the locations of their major landing ports and a rough sketch of hydrographic conditions in the study area are given in Fig. 1.

The statistical data concerning the catches of Todarodes pacificus dealt with in this report were taken from

the following: (1) the statistics of monthly catch by the angling fishery* and the number of fishing boats which sailed out fishing at Kushiro, Hachinohe, Kuji, Miyako, Kamaishi, Ofunato, Onagawa and Katsuura and (2) the statistics of the monthly catch by the set-net fishery at Miyako, Kamaishi, Ofunato and Onagawa recorded in "The amount of landing at various major ports of Todarodes pacificus, Ommastrephes bartrami, Pneumatophorus japonicus and Sardinops melanosticta" (Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory 1965-1986), (3) the statistics of the monthly catch by trawlers collected from 1965 to 1985 at Miyako and Kamaishi by the Iwate Prefectural Fisheries Experimental Station and at Onahama by the Fukushima Prefectural Fisheries Experimental Station and (4) the statistics of the monthly catch by the angling and set-net fisheries at Nishiki collected by the Mie Prefectural Fisheries Technical Center from 1968 to 1985. Generally the catch fluctuations do not necessarily reflect those of the resources. However, with regard to Todarodes pacificus in the Hokkaido-Tohoku coastal waters of the northern Pacific Ocean, it is known that the catch reflects well the level of the migrating resource (MURATA and ARAYA 1977). Therefore the trend of the resource is discussed based on that of the catch in this report.

---

* The catches at other fishing grounds were excluded in the catch statistics by the angling fishery.

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

In addition to the catch statistics of Todarodes pacificus, the catch statistics of Engraulis japonica, Thunnus thynnus, Ammodytes personatus and Euphausia pacifica were studied in order to investigate the variation of the conditions of the biological environment surrounding Todarodes pacificus. As for Engraulis japonica and Thunnus thynnus, "The Annual Report of the Fishery • Aquaculture Production Statistics" (Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries 1964-1985) was consulted. As for Thunnus thynnus in the Sanriku coastal area, the monthly catch statistical data on those landed as the catch by the set-net fishery at Miyako, Yamada, Otsuchi, Kamaishi and Ofunato collected by the Iwate Prefectural Fisheries Experimental Station from 1966 to 1985 were used. As for Ammodytes personatus, the monthly catch statistical data collected by the Miyagi Prefectural Fisheries Experimental Station at various coastal districts in Miyagi Prefecture from 1975-1985 were used. As for Euphausia pacifica, the monthly catch statistical data collected by the Ibaraki Prefectural Fisheries Experimental Station at various Joban coastal districts from 1975 to 1985 were used.

Furthermore, in order to evaluate the effects of the hydrographic changes on the catch fluctuation of Todarodes pacificus, the movement of the First Oyashio Intrusion was studied following the investigation done by OGAWA, HIRAI and YASUDA (1987) based on the water temperature distribution

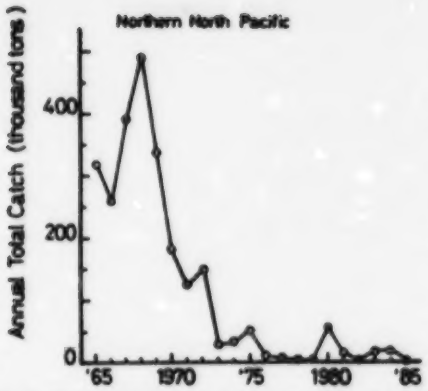

Fig. 2 Fluctuation in annual total catch of *Todarodes pacificus* in northern Japanese coastal waters of the Pacific Ocean from 1965 through 1985. The annual catch drastically declined between 1969 and 1973.

chart at 100 m depth in "the General Report on the Hydrographic Conditions in the Fishing Grounds of the Tohoku Sea Area" (Tohoku Regional Fisheries Research Laboratory 1964-1985).

3. Catch-fluctuation patterns

(1) Trend in the annual catch in the northern Japanese coastal waters of the Pacific Ocean

When observing the trend in the annual catch of Todarodes pacificus by angling after 1965 in the whole area p. 3
of northern Japanese coastal waters of the Pacific Ocean which covers from the Sanriku coast to Doto sea area, first of all, one sees a drastic decline from the latter half of the 1960's to the early 1970's (Fig. 2). That is, after showing a peak of about 490,000 tons in 1968, the annual catch declined almost linearly and dropped to 30,000 tons

in 1973, five years later, less than 1/16 of the 1968 peak. Thereafter, in 1977, it dropped to 7,269 tons, breaking a 10,000 ton level. After the sudden decline from 1969 to 1973, although there have been occasional small peaks such as in 1975 and in 1980, the level of the catch as a whole has been low, staying more or less at the 10,000 ton level. A sign of recovery has not yet been seen.

SHIBATA (1984) has divided the annual catch into "the good catch era", up to 1971 and "the poor catch era", after 1972, based on the trend in the yearly fluctuation of the catch of Todarodes pacificus in the coast of Chiba Prefecture. With regard to the northern sea area of the Pacific Ocean, it is considered as appropriate from Fig. 2 to divide the period into "the good catch era", up to 1969 and after going through a period of transition (or a period of decline) from 1970 to 1972, "the poor catch era" after 1973. The important point given by the difference between the division based on Fig. 2 and that by SHIBATA is that the northern sea area of the Pacific Ocean extending from the Sanriku coast to the Doto sea area had entered the poor catch era two years earlier than the Chiba coast in the southern area of the Pacific Ocean. The fact that a time lag exists between the south and the noth in the catch fluctuation which is thought to reflect directly the resource fluctuation suggests that Todarodes pacificus also reduces its distribution area from the north to the south during the

declining period of its resource similar to the case of floating fishes caught abundantly (OGAWA 1987).

(2) Catch-fluctuation patterns for the angling fishery in coastal areas

After a catch peak in 1968, a drastic decline occurred in the catch in the entire northern sea area of the Pacific Ocean over a very short period from 1969 to 1973. The catch fluctuations of Todarodes pacificus for the angling fishery in the various coastal districts during this sudden change (Fig. 2) were investigated (Fig. 3). The catch in the various districts have declined in general since 1969, a characteristic tendency common to the entire northern sea area of the Pacific Ocean. The decline is observed most clearly for the fishing grounds off Kushiro and Hachinohe in the north. However, the decrease during the declining period was gradual at the southern fishing grounds and an extreme reduction has not been observed at the fishing grounds south of Ofunato. In particular, when one compares the patterns among fishing grounds off Kushiro, Hachinohe and Kamaishi where the catch was relatively great, one sees that the fishing ground off Kushiro in the north had already entered the poor catch era in 1971 whereas the fishing ground off Kamaishi in the middle area was still in transition in 1971 and the declining tendency still continued to 1973. That is, during a period of great change in the catch which reflects a great change in the resource level, the catch decreases much earlier at

the northern fishing grounds in the case of floating fishes caught abundantly in the northern sea area of the Pacific Ocean (OGAWA 1987). The same tendency is also obeserved for Todarodes pacificus.

On the other hand, a slightly different fluctuation pattern is observed at the fishing grounds where the catch is relatively small. For instance, a difference is observed for the comparatively close fishing grounds off Kuji and Miyako. The catch has been declining steadily since 1968 at the fishing ground off Kuji but at the fishing ground off Miyako, the catch showed a tendency to increase from 1965 to 1972. However, the CPUE---a monthly catch per boat per trip --- strongly indicates that the increase at the fishing ground off Miyako from 1965 to 1972 was possibly brought about by an increase in the number of fishing boats sailed out fishing although the data cannot be said to be sufficient. Thus some apparent differences in detail are observed among the fishing grounds but as a whole a trend common to the entire northern area of the Pacific Ocean is recognized. That is, a valley in the catch fluctuation appeared in 1973 at the various fishing grounds except at the fishing ground off Katsuura in Boso.

With regard to the CPUE, although data are not available for some years, it began to decrease a little after 1969 and continued to do so until about 1973 and has been at a low level since then. Therefore, on the whole, it resembles

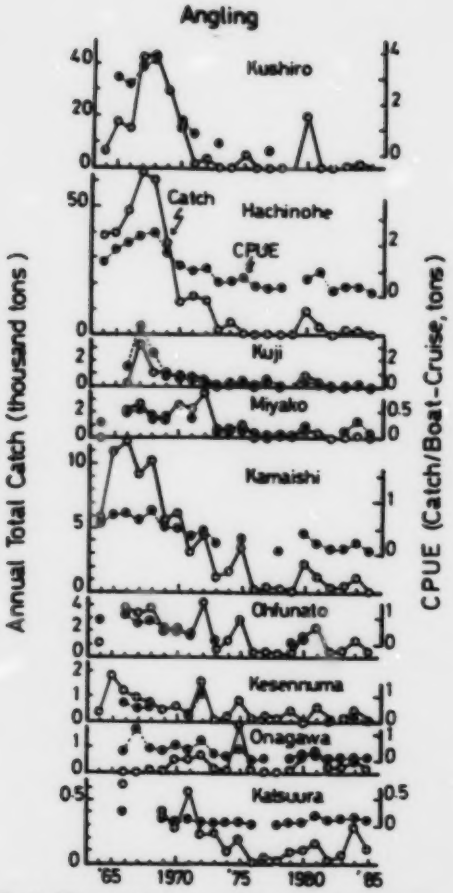

Fig. 3 Fluctuations in annual total catch (open circles)/CPUE (solid circles) by angling fisheries at major fishing ports along the northern Japan coast shown in Fig. 1. According to the fluctuation patterns, an era of good catches before 1968 and a poor catch era after 1972 can be identified. During the poor catch era, favorable peak catches occurred in 1975, 1980, 1981 and 1984.

the fluctuation of the catch (Fig. 3). That is, the CPUE is high during the good catch era and low during the poor catch era. However, during the good catch era, the number of p. 4 angling fishing boats which sailed out was also large but

with the deterioration of the catch, the number decreased considerably. The performance for the coastal squid angling fishery (see Fig. 21) indicates the decrease in the CPUE is not that drastic compared with that of the catch. From the levels of the catch and the CPUE and their fluctuation tendencies, the catch by the angling fishery is divided into the following three periods: (1) the good catch era before 1969, (2) the transition period (or the decreasing period) from 1969 to 1972 and (3) the poor catch era after 1973. Especially during the four years from 1976 to 1979, every fishing ground except that off Katsuura in the south experienced a considerably poor catch.

Now, we regard the period from 1965 to 1969 as representing the good catch years and that from 1976 to 1979, the poor catch years. When the seasonal fluctuation patterns of the catches during these two periods are compared, a clear difference is observed between the good catch era and the poor catch era (Fig. 4). In the former, except the fishing ground off Kushiro in the north, a peak-catch period was observed twice, one in July to August in the summer and the other in November in the autumn. However, for the latter, the beginning of the fishing season was late as a whole and the peak-catch period was not clearly defined. A major difference can be observed, namely the maximum value of the catch in the seasonal fluctuation during the poor catch era was extremely low but compared with the good catch era, the

time of occurrence of the maximum value in the summer was later appearing mainly in August to September. The maximum value of the catch in the autumn which was evident in the good catch era did not appear or if appeared, it was relatively small compared to that in the summer. As shown clearly in the example at the fishing ground off Kamaishi in the middle area of Sanriku, this suggests that the structure of the catch group in the poor catch era is different from that in the good catch era---previously the winter group was the main target of the catch but the percentage which the winter group occupied became smaller with the decrease in the resource level of the winter group (SASAKI 1987).

When the appearance of the seasonal catch peak---the maximum value of the catch over the seasonal fluctuation---is studied, during the good catch era, except for the single peak in September at the fishing ground off Kushiro, double peaks appeared in July-August and in November almost in all areas and there was almost no difference in the time of appearance of the catch peak according to the fishing ground. For instance, the catch peak in the autumn appeared in November at the fishing ground off Hachinohe in the north and at that off Katsuura in the south. Since the migratory speed of Todarodes pacificus is about 0.3 kt at the most (see, for instance, SADAKATA 1982), if the catch peak reflects the migration from the south to the north of the target group of the main catch of Todarodes pacificus, a difference should

be observed even in the time of peak appearance by month at the fishing grounds off Hachinohe and Katsuura, however, that is not so in reality (Fig. 4). The same can be said for the poor catch era. When the fishing grounds off Hachinohe and Kamaishi are compared, the catch peak in the summer appears two month earlier at the fishing ground off Hachinohe in the north (Fig. 4). Such a phenomenon in which the high season comes at the same time to the southern and the northern fishing grounds and sometimes earlier to the north gives an important indication with regard to the supply course of Todarodes pacificus group to every fishing ground. At least, the maximum value of the catch in the seasonal fluctuation cannot be said to reflect simply the maigration of Todarodes pacificus from the south to the north.

Now, let us look at the poor catch era after 1973. p. 5
Roughly speaking, both the catch and the CPUE are at very low levels compared to the good catch era before 1969. However, several characteristic fluctuation patterns can be observed while going through a period of low level (Fig. 3). Above all, the most noticeable point is the appearance of "a favorable catch year" with somewhat large catches in 1975, 1980, 1981 and 1984 during the poor catch era. The catch peak of 1975 does not appear in the annual fluctuation of the catch at the fishing ground off Hachinohe but it is clearly observed in that of the CPUE and is also observed at the fishing ground off Katsuura in the south. At the same

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

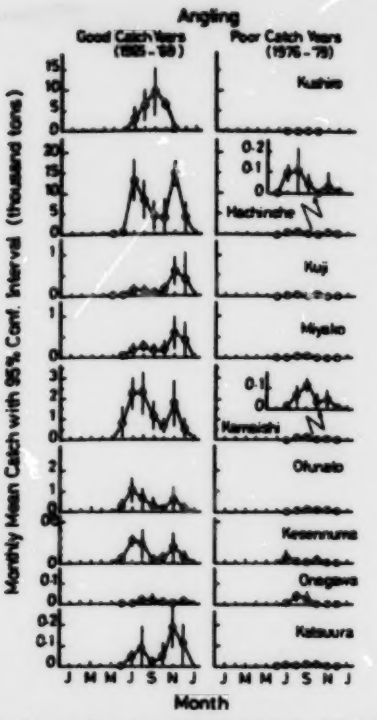

Fig. 4 Comparison of seasonal patterns of monthly catch of *Todarodes pacificus* between good and poor catch years. During good catch years, two clear seasonal peak catches occur in early summer and autumn; during poor catch years, only one low peak appears in summer.

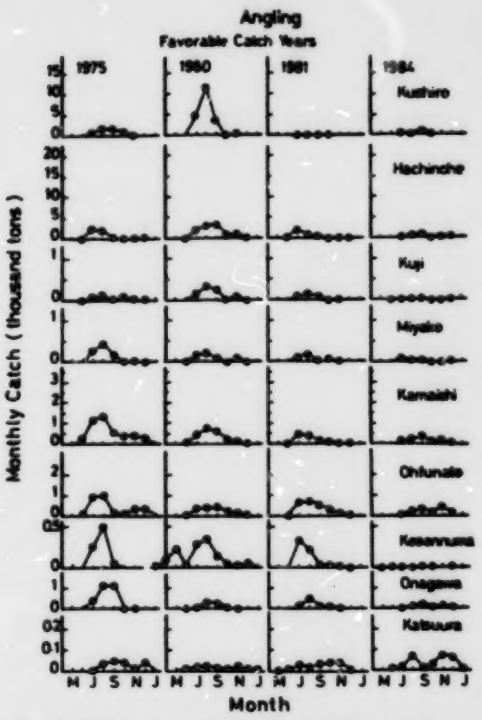

Fig. 5 Seasonal patterns of monthly catch of *Todarodes pacificus* in the four favorable peak catch years shown in Fig. 3. The patterns are similar to those in poor catch years rather than those in good catch years.

time, among "the favorable catch years", the catch peaks in 1975 and in 1980 appear clearly and commonly from the fishing ground off Katsuura in the south to that off Kushiro in the north. However, the catch peaks in 1981 and in 1984 appear clearly at the southern fishing grounds but not so clearly at the northern fishing grounds. Thus differences in the patterns by year are observed.

When the seasonal fluctuation patterns of the catch in these "favorable catch years" are studied (Fig. 5), the

following characteristics are observed. (1) A high peak of the catch appears only once. (2) This high peak of the catch appears mostly in August and September in the summer. (3) In November in the autumn, only low peaks are observed in some years and at some fishing grounds but they are very small compared with the peaks of the summer catch. These characteristics are clearly common characteristics in the poor catch era (Fig. 4) and are different from those in the good catch era.

One noticeable feature in the comparison of Figs. 4 and 5 is that, for the fishing ground off Onagawa in southern Sanriku, the scale of the catches in "the favorable catch years" (Fig. 5) is ten times larger than that in the good catch years or in the poor catch years (Fig. 4). In fact, the catches in "the favorable catch years" at the coastal fishing grounds in southern Sanriku from Ofunato to Onagawa are either equal to or higher than the mean catch in the good catch era (Figs. 3-5). This phenomenon is interpreted as another indirect indication that the structure of the target group of the catch in the poor catch era is different from that in the good catch era. However, these characteristics which are observed at the coastal fishing grounds in southern Sanriku are not observed at the fishing ground off Katsuura situated in the southernmost area. The fishing ground off Katsuura seems different from the fishing grounds in the north in that the peak of the catch in November in the

p. 6

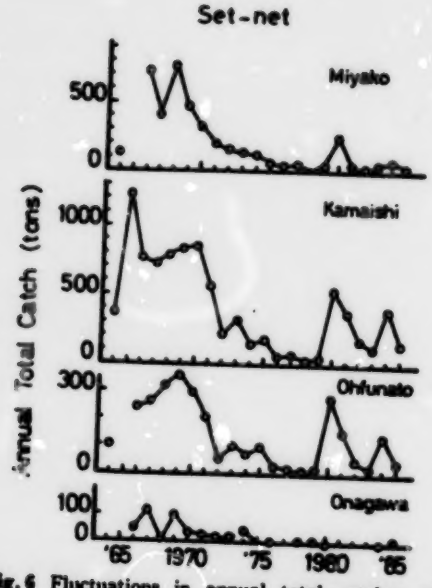

Fig. 6 Fluctuations in annual total catches of *Todarodes pacificus* by set-net fisheries along the Sanriku coast shown in Fig. 1.

autumn is relatively large and clearly indicated (Fig. 5).

(3) Catch-fluctuation patterns for the set-net fishery

Data on the catch of Todarodes pacificus by the set-net fishery available for use are those for the fishing grounds from Miyako to Onagawa on the Sanriku coast (Fig. 6). With regard to the following points, the annual fluctuation patterns as a whole are similar to those for the angling fishery (Fig. 3). (1) The catch changed from the good catch era to the poor catch era by the early 1970's. (2) The change from the good catch era to the poor catch era began earlier in the north than in the south. (3) After entering

the poor catch era, "the favorable catch year" occurred in 1975, 1980, 1981 and 1984.

On the other hand, some patterns are different from those for the catch for the angling fishery (Figs. 3 and 6). For instance, compared with the catch by the angling fishery, the change from the good catch era to the poor catch era occurred about two years later. It is different from the annual fluctuation of the catch by the angling fishery in that the catches at the fishing grounds around Miyako situated in the north began to decrease from 1969 the same time as those by the angling fishery but at the fishing grounds around Ofunato, the decrease began from 1970. At the fishing grounds around Kamaishi further north, the decrease began gradually from 1971. The so called "summer net" is used mainly as a form of operation at the fishing grounds around Ofunato and Onagawa (Fig. 7). The annual fluctuation patterns of the catch by the set-net fishery especially at the fishing grounds around Onagawa are different from those by the angling fishery and from those by the set-net fishery at other fishing grounds. Furthermore, in comparison with the catch by the angling fishery, the catch peak in 1975 during "the favorable catch years" did not appear as clearly as that of the angling fishery. Especially at the fishing grounds around Miyako, it was not recognized as the catch peak for the set-net fishery (Fig. 6).

Based on the annual fluctuation patterns of the

catches (Fig. 6), as in the case of the angling fishery, the catches by the set-net fishery are divided into the good catch era represented by the years from 1965 to 1969 and the poor catch era represented by those from 1976 to 1979. When the seasonal fluctuation patterns of the catches of both eras are compared, a clear difference according to the era is observed (Fig. 7). As stated before, at the fishing grounds around Ofunato and Onagawa in the south, the "summer net" is used mainly in the operation and there is no catch peak in the autumn. However, at those around Miyako and Kamaishi, during the good catch era, two high season periods are observed, one in July-August in the summer and the other October-November in the autumn. On the other hand, the high season period itself is not clearly defined during the poor catch era. When the fishing grounds around Kamaishi are studied where the seasonal peaks of the catch, though low, are seen, it can be seen that the times of appearance do not change greatly for both the good and the poor catch eras. This also indicates that there is a difference in the characteristics of the fluctuations according to eras from those by the angling fishery (Fig. 4).

Detailed comparison with the seasonal fluctuation patterns of the catch by the angling fishery reveals differences in the patterns of the catch which seem to be caused by the differences in the type of fishery (Figs. 4 and 7): (1) The fishing season for the set-net fishery begins

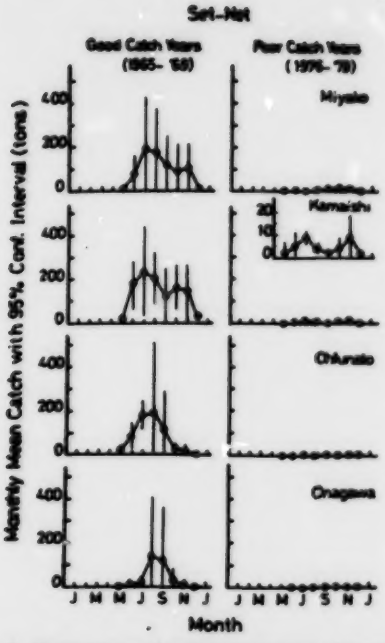

Fig. 7 Comparison of seasonal patterns of monthly catch of *Todarodes pacificus* by set-net fisheries between good and poor catch years.

about one month earlier than that for the angling fishery. The tendency is especially pronounced during the good catch era. (2) The time of appearance of the seasonal peaks of the catch in the good catch era tends to be early in the set-net fishery. Especially this tendency is clearly observed for the peaks of the catch in the autumn. ABE (1985) made a comparative study of the formation of the mantle lengths of Todarodes pacificus caught by the angling and set-net fisheries in 1984 in the middle coast of Sanriku. He stated that "the formation of the mantle lengths of Todarodes pacificus caught by the set-net fishery corresponds well to the actual

condition of the migrating resource". Therefore it is p. 7
necessary to consider that the special nature of the fishing-gear used in the angling fishery with its selectivity (for instance, YAMAGUCHI 1979) is possibly reflecting on the differences mentioned before in (1) and (2) which appeared in Figs. 4 and 7.

As for the mode of appearance of the seasonal peak of the catch by the set-net fishery (Fig. 7), the following should be noted. The peaks in the summer appeared one month earlier at the fishing grounds around Kamaishi and Miyako in the north than at the fishing grounds around Onagawa and Ofunato in the south. The high season came earlier to the fishing grounds around Ofunato than to those around Onagawa. As for the peaks of the catch in the autumn, they were not clear at two fishing grounds in the south since they were operating mainly by the 'summer net". However, the autumnal high season came one month earlier to the fishing grounds around Kamaishi which are further south than those around Miyako. From these facts and the characteristics of the mode of appearance of the seasonal peaks of the catch by the angling fishery indicated in the previous section (Fig. 4), we can see that the catches of Todarodes pacificus at various fishing grounds in the northern coast of the Pacific Ocean do not simply reflect the south to north migration of Todarodes pacificus as claimed by YASUI and others(1972a). The movement and the migration of Todarodes pacificus including

the problem of the supply mechanism to the coastal fishing grounds should be reexamined in detail in future.

(4) Catch-fluctuation patterns for the trawl fishery

The fishing grounds where Todarodes pacificus are caught in relative abudance by trawlers operating in the Tohoku sea area are those in the north centered offshore of Hachinohe and those off Joban and Boso in the south. The catches are relatively small at the fishing grounds in the middle and to the south of Sanriku. Let us look at the catches by the trawl fishery at the three ports, Miyako, Kamaishi and Onahama (Fig. 8). Reflecting the difference in the distribution of Todarodes pacificus at these fishing grounds using trawlers, the landings at Kamaishi Port were not large except for a small peak in 1969. The annual fluctuation patterns of the catch of Todarodes pacificus by the trawl fishery are considerably different from those by the angling and set-net fisheries. They also differ greatly depending on the sea area.

It is thought that the following factors influence the great differences observed between the catches by the trawl fishery and by the angling and set-net fisheries: (1) the changes in the fishing-gear and the fishing methods of the trawl fishery (OKIZAKI 1985, TAKEUCHI and others 1984), (2) the increase in tonnage or in horse power of the main motor of the trawlers themselves (Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory 1980), (3) With the

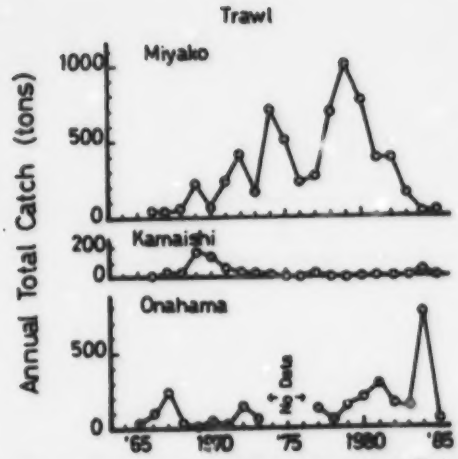

Fig. 8 Fluctuations in annual total catch of *Todarodes pacificus* by trawlers at three ports shown in Fig. 1. The fluctuation patterns are considerably different from those in catches by angling/set-net fisheries. It is noteworthy, however, that landings at Onahama Port are favorable in 1980, 1981 and 1984 when angling/set-net fisheries show peak catches. No data is available for 1975.

decrease in the catch by the angling fishery which has been the major Todarodes pacificus fishery (Fig. 3), fishing began to be undertaken in shallower waters targetting Todarodes pacificus (HASHIMOTO 1980, Hachinohe Branch, Tohoku Regional Fishereis Research Laboratory 1980). It is also thought p. 8 that the fish price of Todarodes pacificus caught by the trawl fishery rose with the decrease in the catch by the angling fishery. Incidentally, the fish price of Todarodes pacificus landed by the trawl fishery was 79 yen/kg in 1966, 205 yen/kg in 1970, 440 yen/kg in 1975 and 837 yen/kg in 1985. It is apparent that the rate of increase during the period from 1966 to 1975 (5.57 times) when the catch by the

angling fishery suddenly decreased is considerably higher than that of the period from 1975 to 1985 (1.90 times).

After the latter half of the 1960's when the catches of Todarodes pacificus by the angling and set-net fisheries began decreasing, the amounts of Todarodes pacificus landed by the trawl fishery at Miyako Port (Fig. 8) continued tendenciously to increase till early 1980's while showing considerable annual fluctuations and have decreased suddenly thereafter. The amounts of Todarodes pacificus landed by the trawl fishery at Onahama Port in the south (Fig. 8) seem to have increased tendenciously since the 1980's when those at Miyako Port began to decrease but the annual fluctuations were large. Both at Miyako Port and Onahama Port, the amounts landed had peaks every several years. However, the times of appearances of the peaks of the catches at both ports did not coincide at all. As for Onahama Port, the amount landed in 1975 is not known because of insufficient data on the amounts landed during the period from 1974 to 1976. However, it should be noted that the amounts landed by the angling and set-net fisheries have relatively increased in 1980, 1981 and 1984 which corresponded with "the lower-level favorable catch years".

With regard to the catches of Todarodes pacificus by the trawl fishery, it is difficult to divide them into the good catch years and the poor catch years in the same sense as those by the angling and set-net fisheries since, as

described before, it is affected by changes in social and economic factors due to the large change in the catch by the angling fishery (Figs. 3, 6 and 8). Therefore, by setting the annual fluctuation at Miyako Port (Fig. 8) as a standard where the amount landed was the greatest among the three ports, the seasonal fluctuation patterns of the catches during two periods were studied. The first period is from 1966 to 1970 when the catch was relatively small and the second from 1976 to 1980 when the catch increased (Fig. 9).

As July and August in the summer are the closed season for the set-net fishery, there is a low catch during this period. The catch increases gradually from September after the closed season is over and the catch peaks are seen at Miyako Port and Kamaishi Port from 1966 to 1970 and at Miyako Port in November to December from 1976 to 1980. As for Onahama Port, the appearance of the catch peak is one month earlier than those at Miyako Port and Kamaishi Port. In both periods, the catch peaks appear in October. The catch by the trawl fishery in May and June, when the season for the angling and set-net fisheries begins and the seasonal catches begin to increase, is extremely small except for that at Onahama Port from 1976 to 1980. This difference can be understood as a reflection of the difference caused by the seasonal natatorial water depth and the area of distribution of Todarodes pacificus. However, it can also be thought that Todarodes pacificus are not the target of the trawl

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

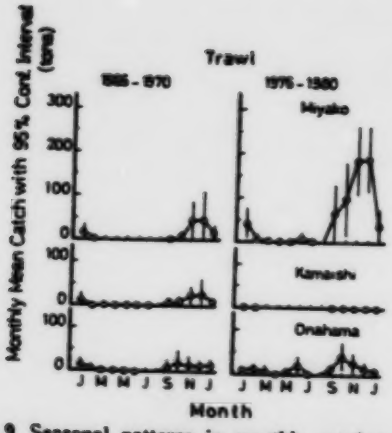

Fig. 9 Seasonal patterns in monthly catches of *Todarodes pacificus* by trawl fisheries. There are few catches in summer because of a closed season for trawlers. There appears a small peak catch in February during 1976-1980 corresponding to poor catch years for angling/set-net fisheries. The February peak suggests the occurrence of a local spring group in the poor catch era.

fishery because their bodies are still small at this time (for instance, ABE 1985) and the price is low.

The most notable characteristic in the seasonal fluctuations of the amounts landed at Onahama Port during 1976 and 1980 is that the maximum value, although weak, is indicated in February. This maximum value is highly characteristic as it does not appear at Miyako Port or at Kamaishi Port and is not seen from 1966 to 1970 at Onahama Port. From the annual fluctuations of the catches by the angling and set-net fisheries (Figs. 3 and 6) and the annual fluctuations of the catches in the whole northern area of the Pacific Ocean (Fig. 2), as described before, it is quite

apparent that the period from 1976 to 1980 is the poor catch era for Todarodes pacificus. Therefore we can regard the fact as a characteristic of the poor catch era in that one peak of the catch though small appears in February in the seasonal fluctuations of the catches of the fleet of fishing boats belonged to Onahama Port operating in the Joban area (Fig. 9).

In relation to this, the biological characteristics of Todarodes pacificus landed at Onahama Port as the catch by the trawl fishery were studied by MATSUI and KAWASAKI (1971). Their results are very interesting. They think that the group which is caught in the offshore of Joban in February has a mode of about 25 cm in mantle length and that the winter maturing group and the spring and summer maturing groups are included in this group. The rate of appearance of mating individuals increases in the period from December to March. Furthermore YASUI and others (1972b) also stated p. 9 that "a considerable number will spawn in winter in the Joban area" based on the results of their analyses and also making reference to the report by OKUTANI (1969) on the distribution of Todarodes pacificus lavae in the Sanriku coast during winter. This indicates clearly the existence of a group in the good catch era which corresponds to the peak group in February in the poor catch era. Therefore it can be said that it is one of the characteristics of the poor catch era that the existence of a local group became

conspicuous due to the overall decrease in all other winter groups but in the good catch era, this group was not conspicuous because the other winter groups were so overwhelmingly abundant. When the amounts of landings in February at Onahama Port in the two periods, form 1966 to 1970 and from 1976 to 1980, are compared, it is necessary to note that the amount is greater for the period from 1976 to 1980 forming a peak in the poor catch era. As described before, this is thought to be related to the increase in the pressure to catch Todarodes pacificus by the trawl fishery in the poor catch era. However, it cannot be denied that there is a possibility of increase in local groups during the period of decrease in the winter groups.

As it has been repeatedly pointed out that the target group for the major catch differs for the poor catch era from that for the good catch era. Furthermore, considering that (1) the percentage of "small Todarodes pacificus" has been increasing in the numbers caught in the poor catch era for the set-net fishing grounds along the Sanriku coast and that (2) these "small Todarodes pacificus" can be thought to be the local groups which come in the spring(SASAKI 1987), the present authors boldly took the amount of the February peak group in the poor catch era landed at Onahama Port by the trawl fishery as a possible index for the number of major spawning groups of Todarodes pacificus. Then the relationship was studied between that amount and the amount of the

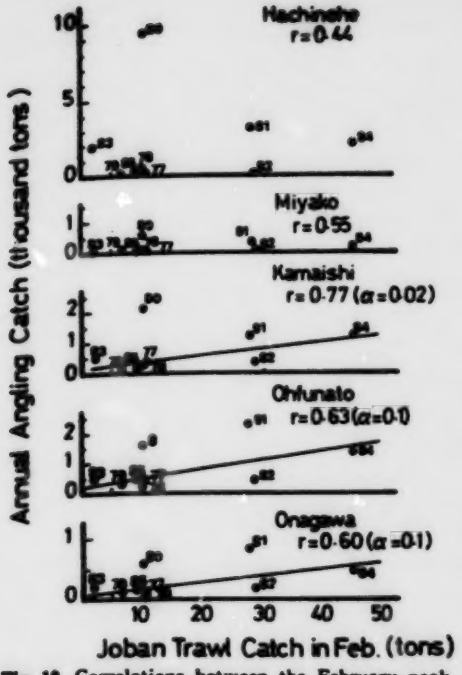

Fig. 10 Correlations between the February peak catches by trawlers shown in Fig. 9 as a local spring group and annual angling catches in coastal waters of northeastern Japan.

catches by the angling fishery after each spring at the various fishing grounds in the Sanriku area (Fig. 10).

Except 1980, the amounts of catches at the various fishing grounds especially south of Kamaishi in the Sanriku coast show a fairly good correlation with the amount landed at Onahama Port in February by the trawl fishery. The fact that, in the poor catch era, a good correspondence is seen in the amounts between the mature groups in February in the coast of Joban and the catch target groups for the angling

fishery at the various fishing grounds in the coast of Sanriku (Fig. 10) strongly supports the interpretation that the major catch target groups themselves change in the good catch era and in the poor catch era (Figs. 3-5). However, it is necessary to note that in 1980 together with 1981 and 1984 which corresponds to "the favorable catch years", good catches were reported at the various fishing grounds in the Sanriku coast in spite of the poor amount landed in February at Onahama Port. This 1980 example suggests the possibility that the Todarodes pacificus fishery fluctuates greatly not only by the quantitative change of Todarodes pacificus themselves but also by the change in the environmental conditions which surround them.

4. Factors influencing catch fluctuations

(1) Evaluation of the biological environmental conditions

The following can be thought to be the three relevant biological environmental conditions for Todarodes pacificus: (1) the condition of the prey species, (2) the condition of the predator species and (3) the problem of competition.

DOI (1962) studied the mutual relationship among the species of the major target species for the catches in Japanese waters by analyzing the statistical data of the catches using an analog computer program based on the models made by VOLTERR (1928). He suggests the possibility that the change in Todarodes pacificus is related to the change

in Engraulis japonica as a prey species and that in Thunnus thynnus as a predator species. Actually, it is well known from the studies of the food habit of Todarodes pacificus that Engraulis japonica is one of the major prey species of Todarodes pacificus (ABE 1981, ARAYA and NAKAMICHI 1962, OKIYAMA 1965, Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory 1957, YAMAKAWA 1977). On the other hand, p. 10 it is thought that the predatory pressure of Thunnus thynnus influences quite strongly the annual occurrence of Todarodes pacificus in the Satsunan sea area and the Ashizuri Misaki area (YOKOTA and others 1961, MATSUDA and others 1972).

When the annual fluctuations are investigated of the catches of Engraulis japonica from the southern sea area of Hokkaido to the coastal waters of Boso in the northern Japanese coastal waters of the Pacific Ocean, it can be seen that the catches are gradually decreasing from the north from the latter half of the 1960's to the first half of the 1970's (Fig. 11) and that the annual fluctuation patterns resemble closely the decline of Todarodes pacificus (Fig. 3). When one looks at the catches of the period from 1964 to 1974 including the period when Todarodes pacificus decreased suddenly in the northern area of the Pacific Ocean, except for 1968, a significant correlation between the two is recognized (Fig. 12).

1968 is the year in which the catches of Engraulis japonica were low at the various coastal districts of the

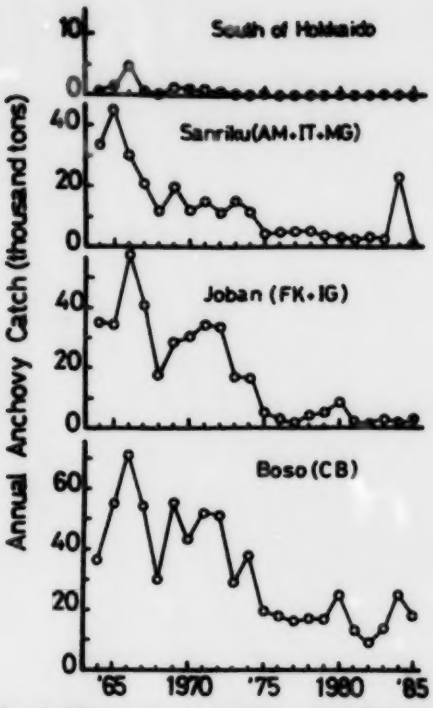

Fig. 11 Fluctuations in annual catch of *Engraulis japonica*, an essential prey species for *Todarodes pacificus*.

northern Pacific Ocean (Fig. 11) whereas the last catch peaks of the good catch era appeared for Todarodes pacificus (Fig. 2). Therefore if the both catches are compared simply, their relation is an inverse correlation. However, the large decline in the catch of Engraulis japonica in 1968 is due to the poor catch of the mature group over two years old called locally "Goboseguro" (HIRAMOTO unpublished data). As for the juvenile of Engraulis japonica which are an easy prey for Todarodes pacificus, it is known that in 1968 the catch was very good in the western area of Tokai region and was average in Kashimanada (Tokai Regional Fisheries Research Laboratory

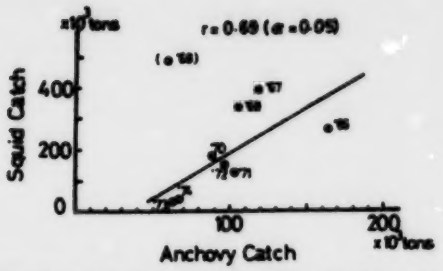

Fig. 12 Correlation between annual catches of the prey species *Engraulis japonica* and the predator *Todarodes pacificus* in northern Japanese coastal waters of the Pacific Ocean, based on data shown in Figs. 1 and 11.

1970). Therefore we can judge that the sudden decrease in Todarodes pacificus and the decrease in Engraulis japonica, one of the prey species, are mutually related, even though there is a year in which the phenomenon is not apparent.

As for the annual fluctuations of the catches of Engraulis japonica after 1973 when Todarodes pacificus entered the poor catch era, we can see that the years 1980 and 1984 in which the catch peaks appeared coincide with "the favorable catch years" of Todarodes pacificus (Figs. 3 and 11). On the other hand, we cannot ignore the fact that the catch peaks for Engraulis japonica which correspond to the years 1975 and 1981 in "the lower-level favorable catch years" of Todarodes pacificus (Fig. 3) are not evident.

However, the organisms which become the prey for Todarodes pacificus are not limited to Engraulis japonica. The stomach contents of Todarodes pacificus caught in the northern Pacific Ocean show many species of prey such as

Euphausia, Copepoda and Temisto in Crustacea and in fishes, Ammodytes personatus and Diaphus coeruleus besides Engraulis japonica. Among them, the importance of Euphausia and Ammodytes personatus is commonly indicated (ABE 1981, ARAYA and NAKAMICHI 1962, Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory 1957). Taking a different view, some conclude that Todarodes pacificus do not have a selectivity of the prey species but rather feed mostly on the living things which are available most in the area where they live at that time (OKUTANI 1962). Euphausia pacifica and Ammodytes personatus are important catch target species in the fishery in the northern Japanese coastal waters of the Pacific Ocean (KOMAKI 1947a,b, ODACHI 1979, 1984, KITAGAWA and YAMASHITA 1986, KODAMA 1980). It is quite natural to think that these p. 11
two species are the important food source for the juvenile of Todarodes pacificus in this sea area.

Actually when the results of the investigation of the appearance are studied of "Konago", the juvenile of Ammodytes personatus and Euphausia pacifica in the poor catch era of Todarodes pacificus (Fig. 13), the following are observed. (1) In 1980 in "the favorable catch years" of Todarodes pacificus, the amount of appearance of the juvenile of Ammodytes personatus was great. (2) In 1981, the amount of appearance was great not only for Engraulis japonica but also for Euphausia pacifica. That is, the three years out of four "favorable catch years" observed during the poor

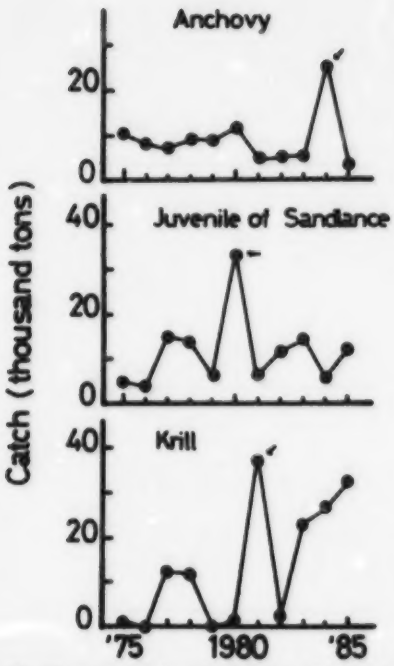

Fig. 13 Fluctuations in occurrences of three typical prey species for *Todarodes pacificus* in coastal waters of northeastern Japan: *Engraulis japonica* (upper), *Ammodytus personatus* (middle) and *Euphausia pacifica* (lower) during a poor catch era.

catch era of Todarodes pacificus agree with the years in which the condition of the prey was good. However, as for 1975, one of the four "favorable catch years", the amount of appearance for Engraulis japonica was a little more than usual and a distinct correspondence with the amount of appearance of the prey cannot be found.

Secondly, the catch fluctuations of Thunnus thynnus were investigated (Fig. 14). It has been indicated that this fish may have a great influence on Todarodes pacificus as a predator. No simple correlation is observed between the

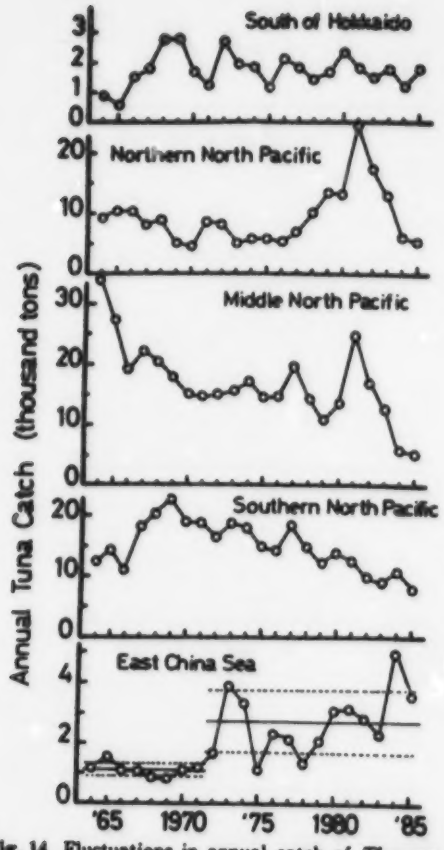

Fig. 14 Fluctuations in annual catch of *Thunnus thynnus*, a major predator of *Todarodes pacificus*.

annual fluctuations of the catch of Thunnus thynnus (Fig. 14) and those of Todarodes pacificus (Figs. 2, 3 and 6) in the southern area of Hokkaido to that of the Pacific Ocean. The difference of the distribution areas is thought to be the reason. That is, the distribution for Todarodes pacificus is tending toward the coastal areas of the Pacific Ocean (KUBODERA et al. 1983, MURAKAMI 1976, MURATA, ISHII and ARAYA 1976, NAITO and others 1976, NAITO and others 1977, OSAKO and MURATA 1983) whereas the distribution for Thunnus

thynnus is spread over a vast area of the northern Pacific Ocean (CHIKUNI 1985, SHINGU, WARASHINA and MATSUZAKI 1974, YAMANAKA 1982).

In order to avert from the problem of the disagreement of the distribution areas, the movement of Thunnus thynnus in the northern coastal waters of the Pacific Ocean was studied based on the annual fluctuations of Thunnus thynnus caught by the set-net fishery along the coast of Sanriku (Fig. 15). The following are the results. (1) There is a time lag between the juvenile ("meji") and the adult ("maguro"). (2) The fluctuations of each repeat in a cycle of several years. (3) The annual fluctuation patterns are p. 12 different from those of Thunnus thynnus in the entire northern area of the Pacific Ocean (Fig. 14). These patterns (Fig. 15) are clearly different from those of Todarodes pacificus (Figs. 3 and 6) and no apparent direct correlation can be found between the two. Therefore it can be said that the predatory pressure of Thunnus thynnus in the sea area around the fishing grounds of the coast of the northern Pacific Ocean is not so great as to influence greatly the catch of Todarodes pacificus.

In relation to the annual fluctuations of the catch of Todarodes pacificus, the annual fluctuation patterns of Thunnus thynnus in the East China Sea (Fig. 14) which is thought to be the major spawning area of the winter group of Todarodes pacificus should be noted rather than those of the sea area around the fishing grounds. The sudden decrease in

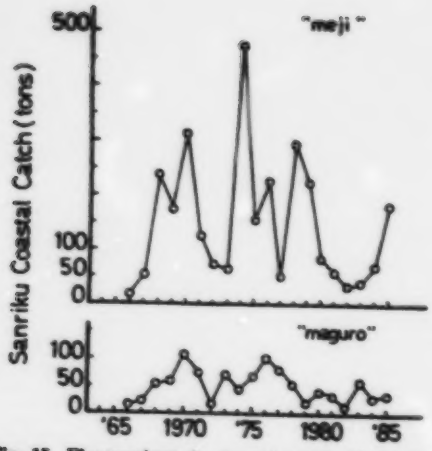

Fig. 15 Fluctuations in annual catch of juvenile ("meji") and adult ("maguro") of *Thunnus thynnus* by set-net fisheries along the Sanriku coast.

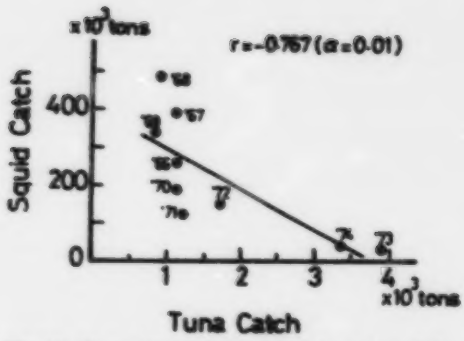

Fig. 16 Correlation between annual catches of the predator species *Thunnus thynnus* and its prey *Todarodes pacificus* in the East China Sea where the major spring group of the squid spawns, based on data shown in Figs. 1 and 14.

Todarodes pacificus in the northern Pacific Ocean from the latter half of the 1960's to the early 1970's (Figs. 2, 3 and 6) is thought to be caused by the considerable decrease in the resource level of the winter group (ARAYA 1985, MURATA and ARAYA 1977, OKUTANI and WATANABE 1983, SASAKI 1987, YASUI 1974). When the annual fluctuations of the catch of Thunnus thynnus are observed in the East China Sea which is the major spawning ground of the winter group during the period of great fluctuation in the resource of Todarodes pacificus, one can see that the catch of Thunnus thynnus increased suddenly in the beginning of the 1970's and around 1972, it doubled compared with those of previous years (Fig. 14). In this connection, a significant negative correlation is observed between the two during the period from 1966 to

1974 in the middle of the fluctuation (Fig. 16). This fact indicates the possibility that the movement of Thunnus thynnus as the predator in the area where the winter group of Todarodes pacificus occur is strongly related to the great fluctuation in the Todarodes pacificus resource---the decrease in the winter group---.

As for the poor catch era of Todarodes pacificus, it is observed that the catch of Thunnus thynnus in the East China Sea in 1975, the first of the four "favorable catch years", was the lowest in "the high level era" for Thunnus thynnus after 1972. Thus the possible explanation of a decrease in the predatory pressure can be suggested as the reason for "the good catch" of 1975 which could not be explained by the condition of the prey species. However, if we think that is the case, then we must conclude that what brought "the good catch" in 1975 was mainly the winter group spawned in the East China Sea and not the local spring group. As pointed out before, the catch peak in 1975 by the angling fishery is clearly evident (Fig. 3) whereas that for the set-net fishery is not necessarily distinct (Fig. 6). This is also different from the other three of "the favorable catch years". A possibility also cannot be denied that the main group of 1975 was the winter group.

Furthermore, when we look at the seasonal fluctuation patterns for the angling fishery in 1975 at the fishing ground off Kamaishi (Fig. 5), it seems that they are closer

to the patterns in the good catch era (Fig. 4) when the winter group was excellent than those in the poor catch era. The authors of this report would like to avoid drawing a conclusion here as to what group brought about "the good catch" in 1975 by leaving the matter to biological experiments and the study of future data. Here, they would like only to point out the importance of the conditions of the prey and the predator species in the Todarodes pacificus fishery.

As for the biological environmental conditions surrounding Todarodes pacificus, the catch fluctuation in the competitive species is also thought to be one of the possible factors influencing the catch fluctuation in addition to the fluctuations in the prey and the predator species discussed above. SATO, IIZUKA and KUBOTA (1975) and SATO (1986) investigated the fluctuations of Pneumatophorus japonicus and Todarodes pacificus at the fishing ground off Hachinohe which is well known as "the Squid and Mackerel Dispute" (KANEDA 1979, OMIHARA 1980) in the history of the fisheries disputes after the World War. They suggest the existence of a spacial occupational relationship (SAISHU 1985) between the two species. It has already been clarified that the great fluctuations of Todarodes pacificus occur in connection with those of Engraulis japonica which is known as an important prey species (Fig. 12). This species is also known as an important prey for Pneumatophorus japonicus (HATANAKA et al. 1957, IIZUKA 1987, NISHIMURA 1958, SATO and

p. 13

UNEDITED TRANSLATION
for information only
TRADUCTION NON REVISEE
Information seulement

others 1975, TAKANO 1954, YAMASHITA 1956, YASUDA 1960). The fluctuations of Pneumatophorus japonicus in the northern Japanese coastal waters of the Pacific Ocean seem to have a close relationship with those of Engraulis japonica, especially in the declining stage (OGAWA 1987). From these studies, it can also be thought that there exist not only a simple spacial occupational relationship but also a possible competition between Todarodes pacificus and Pneumatophorus japonicus. However, as ELTON (1933, 1958) has pointed out, "competition" is a very difficult ecological problem and should be the subject of future field studies.

(2) Evaluation of the hydrographic environmental conditions

The northern Japanese coastal waters of the Pacific Ocean is an area full of changes in time and space (for instance, KAWAI 1972, KAWAI and SAITOH1986, KAWAMURA et al. 1986, MIZUNO 1984, MIZUNO and WHITE 1983, TOMOSADA 1978, 1986 etc.). In the coastal waters where the fishing grounds for Todarodes pacificus are found, it has been indicated that the First Oyashio Intrusion is an important oceanographic phenomenon affecting the environment for marine life (OGAWA and others 1987). SUZUKI (1963) stated that the form of the fronts of the Tsugaru warm current and the Oyashio---the First Oyashio Intrusion---is an important factor influencing the movement and the migration of Todarodes pacificus in the autumnal southward period in the good catch era in the latter

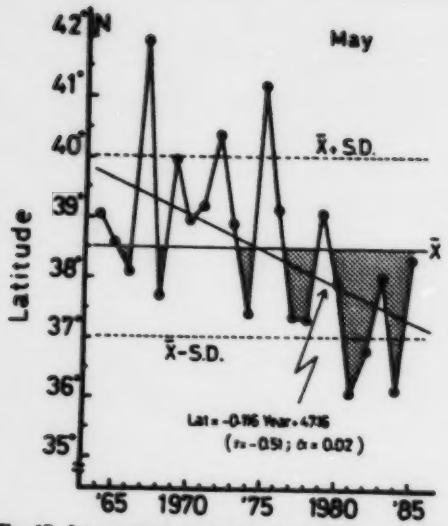

Fig. 17 Interannual variations in location of the southern limit of the First Oyashio Intrusion in May.

half of the 1950's. Todarodes pacificus which is the catch in this area has been considered as having three seasonal groups (ARAYA 1967, ARAYA and ISHII 1972, KAMIMURA 1972, KAWASAKI 1972, MATSUI and KAWASAKI 1971, SUZUKI 1980). The course of the appearance of these groups is different in the good catch era and in the poor catch era (SASAKI 1987) and there are many unknown aspects (YASUI and others 1972). However, many scholars agree that the area of reproduction is to the south of the Joban area. Therefore it is possible to conclude that the group of Todarodes pacificus which becomes the catch target at the various fishing grounds in the northern coastal area of the Pacific Ocean is the group which is reproduced in the area south of the Joban area and

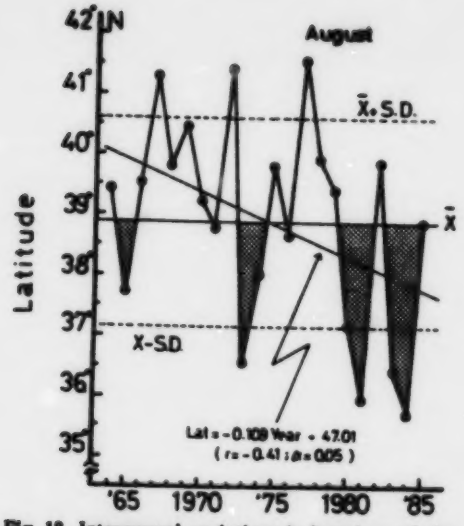

Fig. 18 Interannual variations in locations of the southern limit of the First Oyashio Intrusion in August.

migrates northward from the spring to the early summer.

Therefore, firstly, the latitude at the southern limit of the First Oyashio Intrusion was investigated (Figs. 17 and 18) for the beginning (the northward period) of the Todarodes pacificus fishery season in May and for the high season in August (Figs. 4, 5 and 7). The latitude of the southern limit of the First Oyashio Intrusion varies greatly from year to year (OGAWA and others 1987). When the annual p. 14 variation of the latitude at the southern limit in this period is studied, in both May and August in the period from 1964 to 1985 ivestigated, a tendency is observed, namely, that the southward movement of the cold water of the Oyashio along the coast is getting more noticeable year by year. For instance, in May in the beginning of the fishery season (the

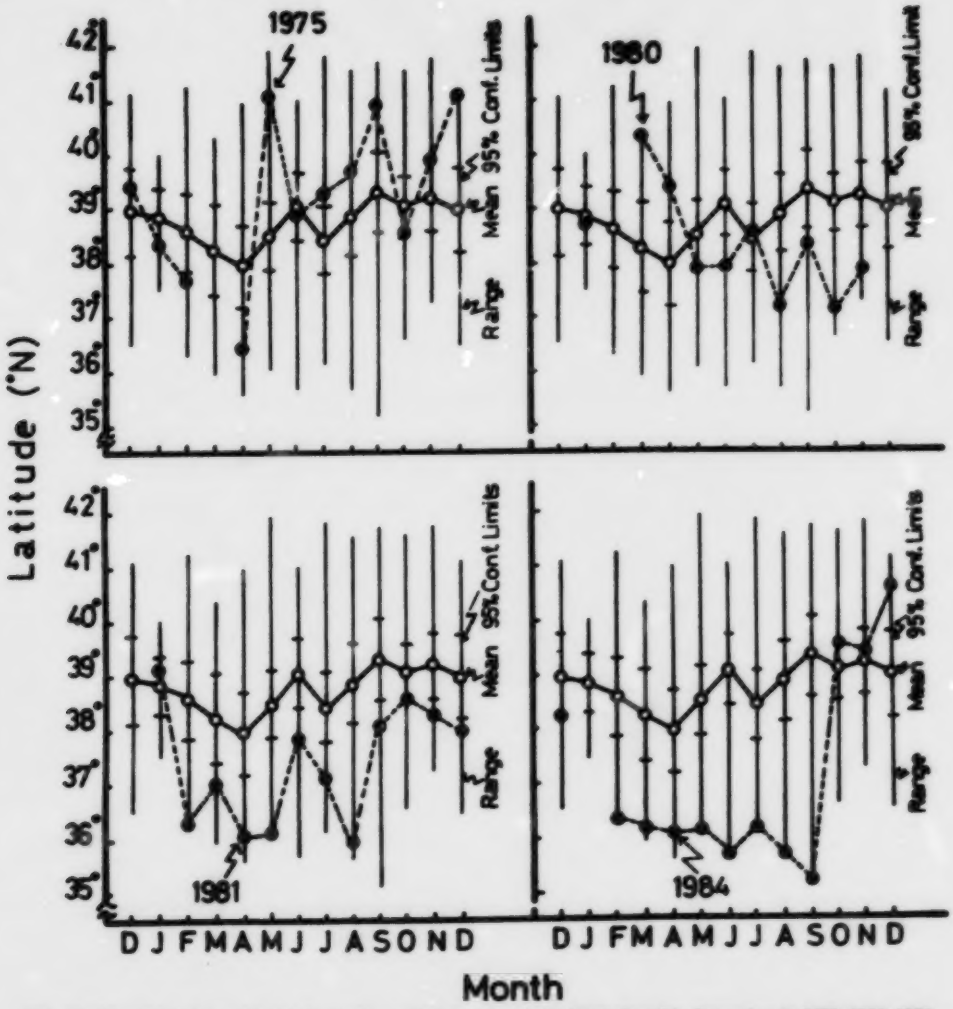

Fig. 19 Monthly plots of latitude at the southern limit of the First Oyashio Intrusion in 1975, 1980, 1981 and 1984 when peak catches occurred as shown in Fig. 3, in comparison with those of mean latitude with 95% confidence limits and range modified after OGAWA et al. (1987).

northward period), the tip of the First Oyashio Intrusion reached the area south of 38°N only twice during the eleven years between 1964 and 1974, once in 1968 and again in 1974. In the next eleven years between 1975 and 1985, this occurred six times (Fig. 17). Furthermore, in these six times, the

location of the southern limit stayed to the north of 37°N for the first three times but for the last three, it reached south of 37°N. Thus one can see the southward movement of the First Oyashio Intrusion has become more noticeable year by year.

Although not as clear as in May in the beginning of the fishery season, the same tendency can be seen in the annual variation of the latitude at the southern limit of the First Oyashio Intrusion in August in the high season (Fig. 18). When these are compared with the annual catch fluctuations of Todarodes pacificus (Figs. 2, 3 and 6), in general, one can see that the era in which the number of occurrences of a year of "the southward mode" (that is, when the First Oyashio Intrusion moves down to the south) is small corresponds to the good catch era and the era in which the number of occurrences of a year of "the southward mode" is large corresponds to the poor catch era. The locational variations of the First Oyashio Intrusion influences directly the coastal water termperatures (OGAWA and others 1987). Therefore, in general, one can regard that the good catch era corresponds to the high temperature era and the poor catch era to the low temperature era. p. 15

As indicated before, the following difference is recognized in the four years of "the favorable catch years" in the poor catch era of Todarodes pacificus. That is, the catch peaks appeared from the fishing ground off Boso

Katsuura in the south to the fishing ground off Kushiro in the north in 1975 and in 1980 whereas in 1981 and in 1984, the catch peaks were clearly indicated at the fishing grounds in the south but not so clearly at the fishing grounds in the north (Figs. 3 and 8). When the movement of the First Oyashio Intrusion in May in the northward period of Todarodes pacificus is studied (Fig. 17) in relation to this phenomenon, one can see that the First Oyashio Intrusion went further southward in 1981 and in 1984 than in 1975 and in 1980. Therefore the movement of the First Oyashio Intrusion was investigated further in detail for the years 1975, 1980, 1981 and 1984 which correspond to "the favorable catch years" (Fig. 19).

Now, the period of northward migration for Todarodes pacificus in the northern Japanese coastal waters of the Pacific Ocean is from April to June, centered about May. When the movement during these four years is studied, we can judge that, even though there was a large fluctuation according to the month during the same period from April to June, the First Oyashio Intrusion proceeded considerably southward in 1981 and in 1984 compared with that in 1975 and in 1980. Furthermore, it is characteristic that in 1981 and in 1984, the First Oyashio Intrusion was tending considerably toward the south compared with normal years not only during the period of northward migration of Todarodes pacificus but also during the high season from the summer to the early autumn. These

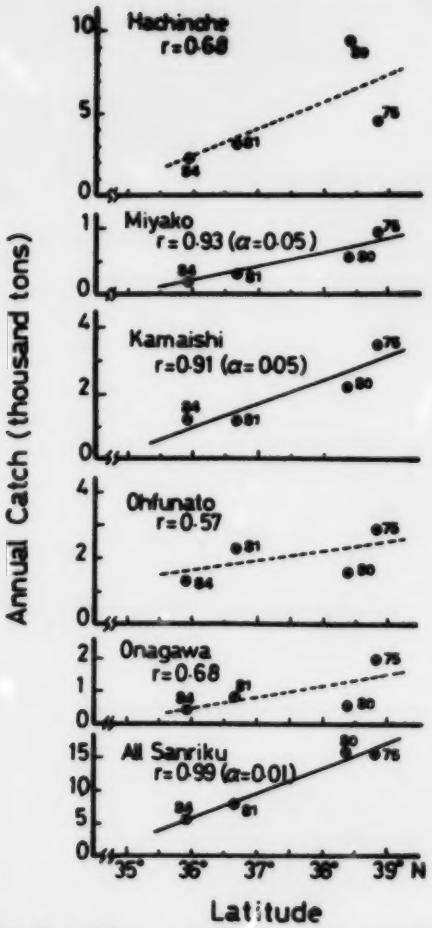

Fig. 20 Correlations between latitudes at the southern limit of the First Oyashio Intrusion and annual catches of *Todarodes pacificus* by angling fisheries in the four peak catch years.

facts suggest a possibility of the strong influence of the movement of the First Oyashio Intrusion on the northward migration, on the distribution and on the catch of Todarodes pacificus.

When the mean latitude at the southern limit of the First Oyashio Intrusion from April to June, the period of

northward migration of Todarodes pacificus and the catches by the angling fisherey of those years at the various fishing grounds of the coast of Sanriku are compared, a significant correlation is observed between the fishing gound off Miyako in the middle area and that off Kamaishi (Fig. 20). The same tendency is observed among the fishing grounds off Hachinohe in the northern area of Sanriku, that off Ofunato in the south and that off Onagawa. However, the relationship is not necessarily significant statistically because the number of data available is small. However, when we look at the coast of Sanriku as a whole, a high correlation is observed between the mean latitude of the southern limit of the First Oyashio Intrusion during the period of northward migration in "the favorable catch years" and the total annual catch by the angling fishery. This indicates that the hydrographic changes are conditions which cannot be ignored for the catch of Todarodes pacificus---especially the geographical distribution (Fig. 20). Now, if we assume that there is a correlation among the fishing grounds and study the inclination of the regression lines shown in Fig. 20, a trend is suggested namely that the inclination is relatively greater at the northern fishing grounds than at the southern fishing grounds. This seems to suggest that the influence of the First Oyashio Intrusion on the supply of the northward migration of Todarodes pacificus becomes greater as the further north the area.

As for 1975, the first year of the four years of "the favorable catch years" in the poor catch era after 1973, the following are observed. (1) A correlation is not found between the year 1975 and the amount of appearance of the major prey species. (2) 1975 coincides with the year of the lowest level in the high level era of Thunnus thynnus as predators in the East China Sea which is the major spawning ground of the winter group. Furthermore, (3) as mentioned p. 16 before, it was possible to suggest that the group which brought "the good catch" in 1975 might have been the winter group based on a slight difference in the catch-fluctuation pattern from those of other three "favorable catch years". Judging from the condition of the southward movement of the First Oyashio Intrusion, it should be noted that in 1975, the hydrographic condition was the best for the supply of Todarodes pacificus migrating northward in the northern Japanese coastal waters of the Pacific Ocean (Fig. 20).

(3) Evaluation of the effect of fishing

The effect of fishing is given as another factor for the decrease in the resource of Todarodes pacificus, especially that of the winter group in the coast of the Pacific Ocean. Broadly speaking, humans can be regarded as a predator species of Todarodes pacificus. However, the fishing action of humans toward Todarodes pacificus is not necessarily the same as the preying behavior of Thunnus thynnus toward Todarodes pacificus. The fishing effort of the angling

fishery of Todarodes pacificus from the latter half of the 1960's to the 1970's increased considerably (ARAYA 1974, 1985). The performances of the squid angling gears and the fish-luring lights have improved compared with those in the past. The fishing ability of the squid angling boat is also improving. In fact, there are not a few who think that the cause of the decrease in the winter group which was the major fishing target at the various fishing grounds in the coast of the Pacific Ocean is indiscriminate fishing due to an excessive input of the fishing effort (ARAYA 1974, DOI and INOUE 1979, HASEGAWA 1985, MURATA and ARAYA 1977).

To test this hypothesis, the relationship was investigated between the number of landing boats and the annual catch of Todarodes pacificus by the angling fishery at Kamaishi Port (Fig. 3) where the data on the number of landing boats are comparatively accurate (Fig. 21). We have already observed that the catch fluctuation of Todarodes pacificus at Kamaishi Port is reflecting well the fluctuation of the Todarodes pacificus resource in the northern Japanese coastal waters of the Pacific Ocean (Figs. 2 and 3). If the excessive input of the fishing effort is the only cause of the decrease in the resource, then as the number of landing boats representing the fishing effort is reduced, the catch should increase (for instance, TANAKA 1985). However, this is not so (Fig. 21). The relationship between the two is linear and the tendency is that the greater the number of

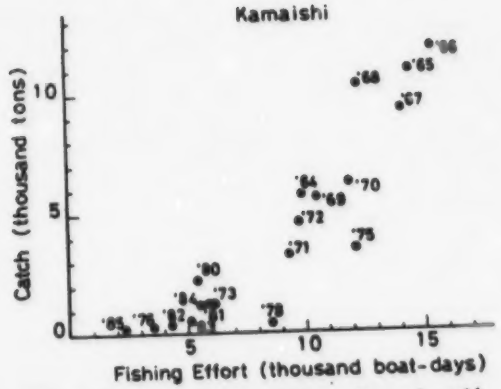

Fig. 21 Relation between fishing effort of squid angling and catches of *Todarodes pacificus* in coastal fishing grounds off Kamaishi..

landing boats the greater the catch. This reflects the actual condition of the angling fishery of Todarodes pacificus that when there is a great amount of catch many fishing boats engage in the squid angling fishery and when the catch is poor, there are fewer trips. Although the data are not necessarily sufficient, the same can be said not only for the fishing grounds around Kamaishi but also for the other fishing grounds in the northern Japanese coastal waters of the Pacific Ocean (Fig. 3).

The fishing effort mentioned here means the number of landing boats. Therefore, in a strict sense, it does not agree with the number of boats which sail out fishing or that of which opperate. No correction has been made according to the difference of the fishing performance of fishing boats era by era. However, at present (the 1980's) which is

a poor catch era, the number of landing boats is 1/3 or lower than that in the good catch era from 1965 to 1968. Therefore from Fig. 21, it is difficult to think that indiscriminate fishing relates directly to the decrease in the resource. At least it is clear that we cannot evaluate correctly the effect of fishing by using a method (for instance, HASEGAWA 1985) of which is applied mechanically to data obtained from a particularly convenient period using a simple model like those of GORDON (1953) and SCHAFFER (1957).

However, financial dependency on the squid angling fishery is high for the following reasons. That is, the fishing grounds for Todarodes pacificus are formed very closely to the coastal areas in the northern Japanese coastal waters of the Pacific Ocean. The ability of Todarodes pacificus to live in shallow waters is excellent. Todarodes pacificus are easy to catch along the coast with small boats. The coastal fishermen do not have any better target species for fishing than Todarodes pacificus during the summer season. Taking these actual conditions of the coastal fishery into consideration, it is rather hard to think that indiscriminate fishing brought about directly the decrease in the resource but it cannot be said that there was or is no influence from fishing.

As for the influence of fishing, the following points can be made. (1) It is possible that excessive fishing

effort accelerated the reduction during the decreasing period of the winter resource from 1969 to 1972. (2) At present, from the actual condition of the coastal squid angling fishery expressed in the relationship given in Fig. 21, there is a possibility of increased fishing as soon as the resource recovers a little. As for the present condition of the squid angling fishery, that of fishing as much Todarodes pacificus as possible, it may happen that the resource will not be able to recover at all. p. 17

At present, in a poor catch era,---a low level period of the resource---, it can be concluded also from our report that the ratio in the catch of the local groups is getting higher and more apparent due to the decrease in the winter group which has been the major target for fishing in the past. As SASAKI(1987) has pointed out, if a local group which is small in quantity becomes the important group for the preservation of the species in a low level period of the resource such as in recent years, it is thought that great attention should be paid to the influence of fishing especially in the low level period of the resource---the poor catch era.

(4) Multiplicity of the influence of environmental conditions on organisms

The Todarodes pacificus catch in the northern Japanese coastal waters of the Pacific Ocean has decreased suddenly since 1969 and in 1973, a valley of the catch was experienced at the various regions. The decrease occurred

early in the north and late in the south (Figs. 3 and 6). Similar to the case of the floating fish species caught abundantly such as Trachurus trachurus, Pneumatophorus japonicus, Engraulis japonica and Sardinops melanosticta (OGAWA 1987), the reduction of the distribution area of Todarodes pacificus from the north to the south has been observed with the decrease in the level of the resource of Todarodes pacificus. Engraulis japonica is one of the important prey species for Todarodes pacificus. The sudden decrease in the level of the resource of Todarodes pacificus occurred at the same time as that of Engraulis japonica in the same northern area of the Pacific Ocean and at the same time as the reduction of the distribution area from the north to the south with the decrease in the resource (Fig. 11). The decrease in the catch of Engraulis japonica and that of Todarodes pacificus show a significant correlation (Fig. 12). On the other hand, if we look at the hydrographic change in the distribution area of Todarodes pacificus in the northern Japanese coastal waters of the Pacific Ocean for this period and take the variation of the location of the southern limit of the First Oyashio Intrusion as an index, the southward movement of the coastal cold water of the Oyashio was observed in a marked degree at about the same time when the distribution areas of Engraulis japonica and Todarodes pacificus were reducing from the north to the south respectively (Figs. 17 and 18).

It is known that the southward movement of the First Oyashio Intrusion decreases directly the water temperature of the coastal waters (OGAWA and others 1987). Therefore it is not unnatural to think that (1) this southward movement of the cold water of the Oyashio not only influenced directly the northward migration of Todarodes pacificus, for instance, as "the cold water barrier" (KAWAI 1975), but also (2) took part in the decrease in the Engraulis japonica resource of "the southern type" by decreasing the sea water temperature (OGAWA and NAKAHARA 1979, OGAWA 1987) and (3) consequently the decrease in the Engraulis japonica resource as a prey species and the reduction of the distribution area affected indirectly Todarodes pacificus. As in this example, a change in the environmental condition not only influences directly a certain organisms on the one hand but also on the other hand influences the organisms twofold or threefold by affecting the other environmental conditions. Therefore the relationship between the organisms and the environment is thought to be an important aspect in the evaluation of the influences of the environmental changes on the organisms.

In relation to the fluctuation of the Engraulis japonica resource, as it has been already pointed out, the catch in 1968 was poor of large-sized Engraulis japonica with "goboseguro", a Japanese local name of Engraulis japonica, as a main catch (Fig. 11). It should be noted that the location of the First Oyashio Intrusion in may, 1968 was at

the southernmost area (Fig. 17) in the high level period of the Engraulis japonica resource which corresponds to the northward migration of the floating fishes which are caught abundantly in the northern area of the Pacific Ocean. However, it is rather dangerous to think that the decrease in the Engraulis japonica resource simply relates with the changes in the physical environment alone. It should also be studied in relation to the floating fish species such as Sardinops melanosticta (NAKAHARA and OGAWA 1979, OGAWA 1979, 1987) which are caught abundantly. However, for the floating fish species which are caught abundantly in Japanese waters, a correlative tendency is observed that "the northern type" of Sardinops melanosticta and Pneumatophorus japonicus are abundant in the low temperature period and "the southern type" of Engraulis japonica and Trachurus trachurus are abundant in the high temperature period. This tendency is also observed in the Tsushima Current area from the East China Sea to the Japan Sea (OGAWA and NAKAHARA 1979). Therefore the relative inclination of the change in the cold water of the Oyashio (Fig. 17) and that in the Engraulis japonica (Fig. 17) resource is thought to be a phenomenon worth noting.

Furthermore it is known that Engraulis japonica which was abundant in the Tohoku sea region was the important prey species not only for Todarodes pacificus and Pneumatophorus japonicus already mentioned but also for many other resource

species such as Katsuwonus pelamis and Thunnus thynnus (KAWASAKI and others 1962, ODACHI 1957). From these considerations, it may be necessary to pay attention to the multiplicity of the influence of the environment on the organisms.

Now, it has been noted that the sudden decrease in the Todarodes pacificus catch in the northern Japanese coastal waters of the Pacific Ocean from 1969 to 1973 (Figs. 2, 3 and 6) corresponds with the sudden increase in Thunnus thynnus (Fig. 15) as a predator species of Todarodes pacificus in the East China Sea---the major spawning ground of the winter group of Todarodes pacificus (Fig. 16). This correlation is very interesting together with the indications made by YOKOTA and others (1961) as mentioned before and by MATSUDA and others (1972).

However, it is not necessarily clear "why Thunnus thynnus had increased in the East China Sea". Although there have been some reports (such as those by ITO 1961, UDA 1957) stating the strong relationship between the change in Thunnus thynnus and that in Sardinops melanosticta and "Fig. 77" in YAMANAKA's report (1982) which indicates the correlation of the changes in these two species. Sardinops melanosticta is the species among the floating fish caught abundantly which shows a reverse correlation pattern with Engraulis japonica (ITO 1961, NAKAHARA and OGAWA 1979, OGAWA 1979, 1987). Therefore it is thought that (1) the decrease in Engraulis

japonica as a prey species of Todarodes pacificus as mentioned before, not only influenced diretly Todarodes pacificus as p. 18
a decrease in the food supply but also (2) the increase in Sardinops melanosticta as a competitive species with the decrease in Engraulis japonica (3) brought about the increase in Thunnus thynnus which feeds on both Sardinops melanosticta and Todarodes pacificus. (4) This increase in Thunnus thynnus as an increase in the number of predators affected the survival of Todarodes pacificus at their early stage of development. (5) Therefore it is possible that the decrease in Engraulis japonica might have influenced indirectly the decrease in the resource of Todarodes pacificus.

Thus the duplicity of the effect of environmental conditions on the organisms is noticeable. That is, on the one hand, the decrease in Engraulis japonica directly affects Todarodes pacificus and on the other hand, affects it indirectly by the change of the superior species within the floating fish species. As clarified before, when considering that the decrease in Engraulis japonica is also related to the changes in hydrographic condition, one must consider that the changes in the hydrographic condition are influencing the changes in Todarodes pacificus twofold and threefold.

When the catch fluctuations of Todarodes pacificus since 1905 in Japanese coastal waters (for instance, "Fig. 16" in ARAYA 1967) are compared with those of Sardinops melanosticta and Engraulis japonica (for instance, "Fig. 1"

in NAKAHARA and OGAWA 1979), we can see clearly that the catch of Todarodes pacificus showed "a large valley" during the excellent period for Sardinops melanosticta in the 1930's before World War II. As for the relationship between the decrease in Todarodes pacificus and the increase in Sardinops melanosticta after the War, TANAKA (1985) also has considered the reverse correlative phenomenon between the two species. It is thought that this apparent relationship of increase and decrease between Sardinops melanosticta and Todarodes pacificus is evidence of the relationship between the species as described in (2)-(5) above. However, when the results of this report are studied, the movement of Thunnus thynnus (Fig. 14) in the regions other than the East China Sea does not seem necessarily to be increasing together with an increase in Sardinops melanosticta (OGAWA 1986) and a decrease in Engraulis japonica (Fig. 11). Each process in the relationship between the species described by (2)-(5) cannot have at present a significance other than that of a working hypothesis. It is thought to be necessary to study these aspects in detail in future from the standpoint of "what is specifically happening in the actual ocean". The problem of "the multiplicity of the effect of environmental conditions on the organisms" may gain a significant foothold at that time.

When considering the multiplicity of the effect of the environmental conditions on the organisms, on the one hand, the environment affects directly and on the other, the

environment affects indirectly through the medium of another process, it is necessary to observe that there are two ways. One set of circumstances tends to produce the same effect as in the case of the relationship between the movement of the First Oyashio Intrusion and Todarodes pacificus given as the first example of the multiplicity whereas another set of circumstances acts in the opposite direction. For instance, Euphausia pacifica appears in abundance in the year when the First Oyashio Intrusion proceeds south (OGAWA and others 1987). As clarified in this report, the appearance of Euphausia pacifica in abundance is one of the feed conditions for "the favorable catch years" of Todarodes pacificus (Figs. 3 and 13). However, the southward movement of the First Oyashio Intrusion which is expected to bring favorable condition leading to the appearance of Euphausia pacifica in abundance at the same time is thought to be unfavoralbe condition for northward migration of Todarodes pacificus (Fig. 20). The evaluation of the effects of the environment on the organisms as a whole is one of the important subjects to be studied in future and in particular, whether the effects of the environment on the organisms act in the same direction or in the opposite direction.

5. Study of the possibility of catch forecasts

The hydrographic changes represented by the change in the prey species and the change in the First Oyashio Intrusion in the northern Japanese coastal waters of the Pacific Ocean

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

are not only related to the large changes in the Todarodes pacificus resource which are expressed by the annual catch fluctuations but also are playing an important role in the yearly fishery fluctuations in the poor catch era of Todarodes pacificus since 1973 as seen in "the multiplicity of the effects of environment on the organisms" explained in the previous section. Among "the favorable catch years" in the poor catch era (Figs. 3 and 6), 1980, 1981 and 1984 coincide with the years in which any one of Engraulis japonica, the juvenile of Ammodytes personatus or Euphausia pacifica which can be abundant feed for Todarodes pacificus in the northern region of the Pacific Ocean were caught in abundance (Fig. 13).

On the other hand, as for 1975, the first year of "the favorable catch years", no such good corresponding relationship was found between the amount of appearance of the prey species (Figs. 3, 5 and 13). However, 1975 falls on the year of "the northward mode" of the First Oyashio Intrusion (Figs. 17 and 19) so that it is thought that the hydrographic condition was good for the warm water species of Todarodes pacificus (Fig. 20). Furthermore 1980 became "a favorable catch year" in spite of the small amount of the February peak group in the offing from Joban which is thought to be the spawning group (Fig. 10). This is thought to be due to (1) the abundance of Euphausia pacifica in the spawning region of Todarodes pacificus, (2) the relative

abundance of Engraulis japonica (Fig. 13) and also the same as 1975, this year is a year in which the First Oyashio Intrusion did not move southward during the period of northward migration of Todarodes pacificus (Figs. 17 and 19). Thus as for the yearly catch fluctuations, we can see that the changes in the hydrographic condition are affecting p. 19 greatly the northward migration and the geographic distribution of Todarodes pacificus (Fig. 20).

As indicated before, the catch-fluctuation patterns of Todarodes pacificus during the poor catch era in the northern Japanese waters of the Pacific Ocean are common to every fishing ground from the coast of Boso to the coast of Kushiro (Figs. 3 and 4). When these patterns and those of the fishing grounds along the coast of Kumanonada in the middle region of the Pacific Ocean are compared (Fig. 22), they are clearly different annually and seasonally. Therefore the patterns of the northern Japanese coastal waters of the Pacific Ocean are regarded as peculiar to that region. In this respect, the following facts are noteworthy. (1) A maximum value, although a weak one, is observed in February in the seasonal fluctuations of the Todarodes pacificus catch landed at Onahama Port by the trawl fishery in the poor catch era(Fig. 9). (2) A good corresponding relationship is observed between this February catch by the trawl fishery and the catch by the angling fishery from the spring onwards at the fishing grounds along the coast of Sanriku (Fig. 10).

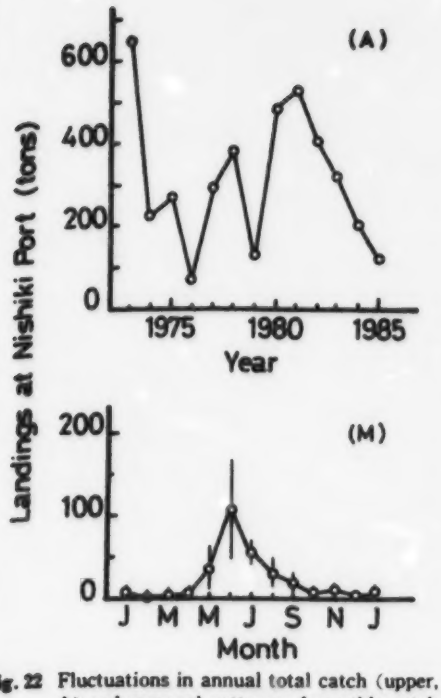

Fig. 22 Fluctuations in annual total catch (upper, A) and seasonal patterns of monthly catch (lower, M) of *Todarodes pacificus* in coastal fishing grounds off Nishiki Port shown in Fig. 1. The annual/seasonal fluctuation patterns are quite different from those in northern Japanese coastal waters.

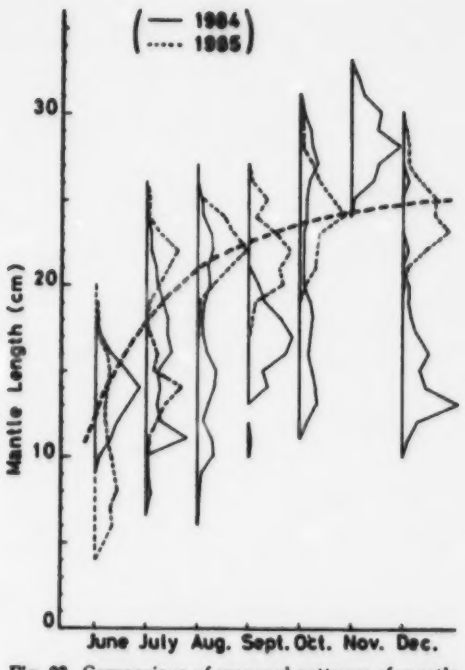

Fig. 23 Comparison of seasonal patterns of mantle length composition of *Todarodes pacificus* caught by set-net fisheries between a good catch year, 1984 and a poor catch year, 1985, modified after SASAKI (1987). The dotted line shows the growth curve of the winter spawning group of *Todarodes pacificus* modified after ARAYA (1967).

These facts strongly support the possibility that the catch target group of mainly August and September which brings "the good catch" in "the favorable years" (Fig. 5) is comprised of the local group which is caught mainly in the northern Japanese coastal waters of the Pacific Ocean alone and at the same time, these facts can be regarded as a basis for a catch forecast.

SASAKI (1987) studied so called "small squids" caught by the set-net fishery along the middle coast of Sanriku.

In the study, he showed the composition of the mantle length by month of Todarodes pacificus which appeared in 1984 and 1985. As clarified before, when these two figures ("Fig. 4" and "Fig. 5" in SASAKI 1987) are compared by regarding one as that of "the favorable catch year" (1984) and the other as that of the poor catch year, one notices that the small-type groups appeared in greater abundance than the winter group in "the favorable catch year" (Fig. 23). An important subject for future study is the determination of the biological connection between these small-type groups and the February peak group caught by the trawl fishery at Onahama Port which was assumed to be the spawning group in the present report. The present authors wish to discuss this in another paper (SASAKI and OGAWA in preparation). p. 20

In conclusion, based on the results in the present report, it is possible to write "a story" as an operational hypothesis for undertaking catch forecasts in future during the fishing season in the poor catch era at the fishing grounds along the northern Japanese coastal waters of the Pacific Ocean. The main points can be put into the following three sections.

(1) The amount of the spring occurrence of the local groups around the Joban sea area---at present, it is estimated by taking as an index the February catch by the trawl fishery at Onahama Port. However, a bilogical study and confirmation are required in future---.

(2) The amount of the distribution of the prey species in the sea area of occurrence and the surrounding area of the fishing grounds---at present, it is estimated by taking as an index the catches of Engraulis japonica, the juvenile of Ammodytes personatus and Euphausia pacifica---.

(3) The movement of the First Oyashio Intrusion mainly during the period of northward migration of Todarodes pacificus---at present, it is estimated by the distribution of water temperature at 100 m depth from April to June---.

Basically an appearance of "a favorable catch year" can be expected if (1) and (2) mentioned above are favorable. It is also possible to estimate to a certain degree from the conditions associated with (3) the degree of "good catch" and the geographical distribution.

There are many points to be studied in future with regard to a long-term catch forecast of more than several years. However, the following will be useful in forming a basis for this objective. (1) The long-term change in the hydrographic condition indicated by the tendency of the long-term change in the First Oyashio Intrusion. (2) The movements of the floating fishes caught abundantly in the Japanese coastal waters including Engraulis japonica as the main prey species of Todarodes pacificus. (3) The movement, which is thought to be changing in relation to the prey species as mentioned above, of Thunnus thynnus as a predator species of Todarodes pacificus in the East China Sea---the

main spawning ground of the winter group---.

6. Summary

Based on the statistical data of the catch from 1964 to 1985, the time and the space fluctuation patterns of the catches of Todarodes pacificus were analyzed at the fishing grounds along the coast of the northern Japanese coastal waters of the Pacific Ocean. The following were studied. (1) In the long term, during the years from 1969 to 1972, the Todarodes pacificus resource suddenly decreased from the northern fishing grounds and the years are divided into the good catch era before the sudden decrease and the poor catch era after. (2) It was clarified that this large decline of the resource bore a relationship with the following. (1) A long-term southward movement of the First Oyashio Intrusion (a tendency to decreasing in water temperature). (2) A decrease in the resource and a reduction in the distribution area of "the southern type" of Engraulis japonica as a prey species of Todarodes pacificus with the movement mentioned in 1. (3) A sudden increase in Thunnus thynnus as a predator species of Todarodes pacificus in the East China Sea which is the major spawning ground of Todarodes pacificus. (4) The multiplicity and the importance of the effects of the environment on organisms whether by the biological or hydrographical environment. (3) There is a strong possibility that the main target group of the catch of Todarodes pacificus in this sea area in the poor catch era is the local group which occurs

around the Joban area. (4) It was clarified that the catch of Todarodes pacificus in the poor catch era depends largely on the following: (1) the amount of occurrence of the local group in the spring around the Joban sea area, (2) the amount of distribution after the above occurrence of the prey species such as Engraulis japonica, the juvenile of Ammodytes personatus and Euphausia pacifica, and (3) the southward movement of the First Oyashio Intrusion during the period of northward migration of Todarodes pacificus. (5) The possibility of a catch forecast based on knowledge obtained and from additional future biological studies for Todarodes pacificus in the poor catch era was discussed in a concrete way.

Acknowledgement

The authors would like to express their deep gratitude to Mr. Tatsuo ADACHI, Chief of the Planning and Liaison Office of the Tohoku Regional Fisheries Research Laboratory, who gave us various suggestions concerning the fishery, resource and biology of Todarodes pacificus and also supervised this report, Dr. Hideo KAWAI, Professor at Kyoto University, who always gave us friendly guidance and who also supervised this report, Dr. Shin'ichi FUKUSHIMA, Head of the Ocean Department of the Tohoku Regional Fisheries Research Laboratory, Dr. Hirosuke TOBE, Head of the Resource Department of the same Laboratory, Dr. Jiro ADACHI, Head of the Ocean Resource Section of the Shimane Prefectural Fisheries Experimental

Station and Mr. Kyoichi ISHIDA, Engineer at the Iwate Prefectural Fisheries Experimental Station. The authors would also like to thank Mr. Terufumi NISHIMURA and Mr. Hirokatsu YAMADA, Engineers at the Mie Prefectural Fisheries Technical Center, Dr. Kikuo HIRAMOTO at the Chiba Prefectural Cultivation Fisheries Center, Dr. Nobuyoshi KUBO, Head of the Environment Department of the Ibaraki Prefectural Fisheries Experimental Station, Mr. Katsumi OKIZAKI, Chief Research Staff at the Fukushima Prefectural Fisheries Experimental Station, Ms. Masako SHIMOYAMA, Engineer at the Miyagi Prefectural Fisheries Experimental Station, Mr. Daiji KITAGAWA, Special Research Staff at the Iwate Prefectural Fisheries Experimental Station, Mr. Toshiaki WAKUTSUBO, Engineer at the Aomori Prefectural Fisheries Experimental Station, Mr. Atsushi NAKADA, Research Staff at the Hokkaidoritsu Kushiro Fisheries Experimental Station and Mr. Shingo KUBOTA, Chief of Research Staff at the Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory for the supply of important data and literatures and for the instructions regarding the actual condition of fisheries and the resource at various districts.

Finally, the authors would like to mention that they were much indebted for the realization of their "joint research" to the members of the Fisheries Department of the Iwate Prefectural Fisheries Experimental Station and those of the Ocean Department of the Tohoku Regional Fisheries Research Laboratory for their warm support and pleasant

discussions.

Bibliography (original from p. 84 of present translation)

1. ABE, Shigehiro (1985) 1984 nen kaki ni okeru Tohoku kaiku okiai kara Iwate-Ken engan eno Surumeika no kanyu ni tsuite (On the entrance of Todarodes pacificus from the offshore Tohoku sea region to the coast of Iwate Prefecture during the summer of 1984). Showa 59 nendo Ikarui Shigen • Gyo Kaikyo Kento Kaigi Kenkyu Hokoku (Bulletin of the 1984 Investigative Council on the Squid Resource and the Hydrographic Conditions for the Squid Fishery) (Hokusuikenhen) (Hokkaido Reg. Fish. Res. Lab. edit.), 45-54 p. 21

2. ABE, Susumu (1981) Surumeika no i naiyobutsu yori mita shokusei ni tsuiteno shohoteki kosatsu (A rudimentary study of the food habit of Todarodes pacificus from stomach contents). ARAKU Moriya hen, ABE Susumu no sokuseki. Iko to tsuitoshu (Moriya ARAKU edit., The footprints of Susumu ABE. The collection of the manuscripts and the memorial papers), 5-16. Shiogama-Shi, Koyosha, 108 pp.

3. ARAYA, Hisao (1967) Surumeika no shigen (The Todarodes pacificus resource). Nihon Suisan Shigen Hogo Kyokai Suisan Kenkyu Sosho (16) (The Fisheries Research Library, Fisheries Resource Protection Society of Japan) (16), 60 pp. Tokyo, Ishizaki Shoten

4. ibid. (1974) Ikatsuri gyogyo shigen no kanri ni kansuru

mondaiten (The problems concerning the management of the resource for the squid angling fishery). Gyogyo Shigen Kenkyu kaigiho (Bulletin of the Fisheries Resource Research Council) (16), 71-78

6. ibid. (1985) Surumeika gyogyo no hensen to shigen no doko (The change in the Todarodes pacificus fishery and the movement of the resource). (Same bulletin as in 1), 1-6

7. ARAYA, Hisao and ISHII, Tadashi (1972) Hokkaido shuhen kaiiki ni okeru surumeika no keitogun (The genealogical group of Todarodes pacificus in the surrounding sea area of Hokkaido). Norin Suisan Gijutsu Kaigi Kenkyu Seika (Report of the Agriculture, Forestry and Fisheries Technical Council) (57), 192-205

8. ARAYA, Hisao and NAKAMICHI, Yoshio (1962) 1959, '60 nen ni chosa sareta surumeika no i naiyobutsu ni tsuite (The stomach contents of Todarodes pacificus investigated in 1959 and 1960). Hokusuishi Geppo (Monthly Report, Hokkaido Reg. Fish. Exptl. Sta.) 19(4), 8-14

10. DOI, Masayuki (1962) Nihon kinkai gyoshu no gyoshukan sogo kankei no kaiseki ni tsuiteno kenkyu (Study of the anayses of the mutual relationships among the fish species in Japanese waters). Tokaisui Kenpo (Bull. Tokai Reg. Fish. Res. Lab.) (32), 49-121

11. DOI, Masayuki and KAWAKAMI, Takehiko (1979) Nihon kinkaisan surumeika no seibutsu seisan to gyogyo no

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

kanri (The organic production and the fishery management of Todarodes pacificus in Japanese waters). ibid. (99), 65-83

12. ELTON, C.S. (1933) The Ecology of Animals. Methuen & Co., Ltd. KAWANABE, Hiroya, MATSUI, Hiroaki, IHARA, Toshiaki, HORI, Michio and YADA, Ichizo yaku (trans.) (1971) Dobutsu no seitai, 293+XX pp. Tokyo, Shisakusha

13. ELTON, C.S. (1958) The Ecology of Invasion by Animals and Plants. Methuen & Co., Ltd. KAWANABE, Hiroya, OSAWA, Hideyuki and ABE, Takuya yaku (trans.) (1971) Shinryaku no seitaigaku, 223+XV pp. ibid.

15. HASEGAWA, Akira (1985) MEY no jirei kaiseki---Nihon kinkai surumeika shigen ni taisuru tekisei kanri eno sekkin--- (The analytical examples of MEY---An approach to the proper management for the Todarodes pacificus resource in Japanese waters---), Gyogyo Kanri, Shin-suisangaku Zenshu (The Fishery Management, The New Fishery Science Series) 35, 103-130. Tokyo, Koseisha Koseikaku, 236 pp.

17. HASHIMOTO, Ryohei (1980) Tohoku kaiku no okiai sokobikiami no gyohobetsu gyokaku seino ni tsuite (The catch performance by fishing method of the offshore trawl fishery in the Tohoku sea region). Showa 54 nendo Gyogyo Shigen Kenkyu Kaigi Kita Nihon Teigyobukai Kaigi Hokoku (Report of the Committee Meeting of the Bottom Fishes in Northern Japan, The 1979 Fisheries Resource

Research Council), 84-92

18. IIZUKA, Kagenori (1987) Tohoku hokubu kaiiki ni okeru masaba miseigyo no seitaiteki chii (The ecological position of juvenile mackerel, Pneumatophorus japonicus in the northern sea region of Tohoku), Tohokusuiken Kenpo (Bull. Tohoku Reg. Fish. Res. Lab.) (49), 35-59
19. ITO, Yoshio (1961) Nihon kinkai ni okeru maiwashi no gyogyo seibutsugakuteki kenkyu (The biological study of the Sardinops melanosticta fishery in Japanese waters), Nissuiken Hokoku (Bull. Japn Fish. Res. Inst.) (9). 1-227
20. Iwate-Ken (Iwate Prefecture) (1984) Iwate-Ken gyogyo-shi (History of the fisheries in Iwate Prefecture). 974+(195) pp. Morioka-Shi, Kumagai Insatsu
21. Iwate-Ken Suisan Shikenjo (Iwate Prefectural Fisheries Experimental Station) (1960) Iwate-Ken no gyogyo no jisso (The actual condition of the fisheries in Iwate Prefecture). Iwate-Ken Suisan Shikenjo Shuroku (Soritsu 50 shunen Kinen) (Iwate Prefectural Fisheries Experimental Station Compilation) (Commemoration of the 50th Anniversary), 445 pp. Kamaishi-Shi, Tokai Insatsusho
22. UEMURA, Kiyotaka (1972) Boso kinkai no surumeika---II. Kanto kinkai no surumeika ni kansuru kenkyu hokokushu (Todarodes pacificus in Boso waters---II. Collection of reports on Todarodes pacificus in Kanto waters) (Tokaisuiken Shigenbuhen) (The Resource Department,

Tokai Reg. Fish. Res. Lab., edit.), 1-9

23. KANEDA, Tomoyuki (1979) Hachinohe gyojo ni okeru shukumei no ika・saba funso (The fatal disputes on squid and mackerel at Hachinohe fishing ground). Gyogyo Funso no Sengoshi (The Postwar History of the Fisheries Disputes), 281-348. Tokyo, Seizando Shoten, 371+VII pp.

25. KAWAI, Hideo (1975) Kaiyo kankyo no tokusei (Characteristics of the ocean environment). HIRANO, Toshiyuki hen (edit.), Kaiyo Seibutsu Shigen Kankyo, Kaiyogaku Koza (The Resource Environment of the Ocean Life, The Ocean Science Lectures) 15, 11-20, Tokyo, Tokyo Daigaku Shuppankai (ibid.), 241 pp.

28. KAWASAKI, Ken (1972) Honpo Taiheiyogawa ni okeru surume-ika no shigen kozo (The structure of the Todarodes pacificus resource in Japanese waters of the Pacific Ocean). (Same report as in 7), 168-180

29. KAWASAKI, Ken, YAO, Masakazu, ARAKU, Moriya, NAGANUMA, Akira and ASANO, Masahiro (1962) Tohoku kaiku ni bunpu suru hyososei gyoshokusei gyorui gunshutai no kozo to sono hendo kiko ni tsuite (The structure and its mechanism for change of the surface fish-feeding fish community distributed in the Tohoku sea region). (Same bulletin as in 18) (22), 1-44

30. KITAGAWA, Daiji and YAMASHITA, Hiroshi (1986) Iwate-Ken enganiki ni okeru ikanago shigyo no shutsugen, bunpu, ido kakusan (The appearance, distribution, movement and

dispersion of juvenile Ammodytes personatus in the coastal area of Iwate Prefecture). Suisan Kaiyo Kenkyu-kaiho (Bull. Fish. Ocean Res. Inst.) 50 (3), 205-212

31. KODAMA, Jun'ichi (1980) Miyagi-Ken engan ni seisoku suru ikanago no keito kozo to shigen jotai (The group structure and resource condition of Ammodytes personatus living in the coastal area of Iwate Prefecture). Miyagi Suishi Kenpo (Bull. Miyagi Pref. Fish. Exptl. Sta.) (10), 1-41

32. KOMAKI, Yuzo (1974a) Nihon engan no okiami gyogyo to sono riyo (The Eupausia fishery and its utilization in the coast of Japan). (Same bulletin as in 30) (24), 49-52 p. 22

33. ibid. (1974b) Okiami, tokuni Nihon kinkai ni okeru tsunonashi okiami ni tsuite (Euphausia, especially Euphausia pacific H. JHANSEN in Japanese waters). JAMARC (5), 2-9

35. MATSUI, Takeshi and KAWASAKI, Ken (1971) Jobanoki ni okeru surumeika no shigen kozo ni tsuite (The resource structure of Todarodes pacificus in the coast of Joban). (Same bulletin as in 10) (64), 57-69

36. MATSUDA, Seiji, HANAOKA, Fujio, KODO, Tsutomu, ASAMI, Tadahiko and HAMABE, Mototsugu (1972) Honpo nansei kaiiki ni okeru surumeika no saiseisan kiko to sono hendo yoin (The reproduction mechanism and the main cause of the change in Todarodes pacificus in the

southwest area of Japanese waters). (Same report as in 7) (57), 10-30

37. MIKAWA, Masao (1980) Tohoku kaiiki teigyo shigen (The bottom fish resource in the Tohoku sea region), AOYAMA, Tsuneo hen (edit.), Teigyo Shigen (The Bottom Fish Resource), (Same series and publisher as in 15) 10, 191-204. 360 pp.

38. MIZUNO, Keisuke (1984) Tohoku kaiku no kaikyo hendo ni tsuite (The hydrographic change in the Tohoku sea region). (Same bulletin as in 18) (46), 61-80

40. MURAKAMI, Koichi (1976) Surumeika shigen kenkyu no genjo to mondaiten (The present condition and the problems of research on Todarodes pacificus resource). Showa 46 nendo Gyogyo Shigenbumon Tantosha Kaigi Gijiroku (Proceedings of the 1971 Committee Meeting of the Fisheries Resource Department) (Hokkaidoritsu Kushiro Suishihen) (Hokkaidoritsu Kushiro Fish. Exptl. Sta. edit.), 1-18

41. ibid. (1976) Hokusei Taiheiyo ni okeru ikarui no bunpu ni tsuite (The distribution of squids in the northwestern Pacific Ocean). (Same report as in 8), 33 (1), 2-18

42. MURATA, Mamoru and ARAYA, Hisao (1977) Surumeika fuyu-umaregun shigen no genjo to mondaiten (The present condition and the problems of the winter group resource of Todarodes pacificus). Nihonkai Burokku Shiken Kenkyu Shuroku (Report of the Japan Sea Bloc Experimental

Res. Inst.) (1), 1-13

43. MURATA, Mamoru, ISHII, Tadashi and ARAYA, Hisao (1976) Hokkaido・Sanriku Taiheiyo kaiiki ni okeru gaiyosei ikarui (akaika, tsumeika, takoika, surumeika) no bunpu ni tsuite (The distribution of the ocean squids (Ommastrephes bartrami, Onychoteuthis boreali japonicus, Gonatopsis borealis, Todarodes pacificus) in the Hokkaido and Sariku area of the Pacific Ocean). Hokusuiken Hokoku (Bull. Hokkaido Reg. Fish. Res. Lab.) (41), 1-29

44. NAITO, Masaharu, MURAKAMI, Koichi, NAKAYAMA, Nobuyuki, KOBAYASHI, Takashi and OGASAWARA, Junroku (1977) Hokusei Taiheiyo ni okeru ikarui no bunpu to kankyo (The environment and the distribution of squids in the northwestern Pacific Ocean). (Same bulletin as in 30) (29), 53-56

45. ibid. (1977) Hokusei Taiheiyo Akantai suiiki ni okeru gaiyosei ikarui no bunpu to kaiyu (The distribution and the migration of squids in the sub-arctic area of the northwestern Pacific Ocean). Hokudai Suisan Hokuyoken Gyosekishu (Tokubetsugo) (Collection of Reports on the North Sea Research, Fac. Fish. Hokkaido Univ.) (Special Issue), 321-337

46. NAKAHARA, Tamio and OGAWA, Yoshihiko (1979) Fugyorui ni okeru takuetsushu no kotai---I. Shigen no choki hendo to bunpuiki no henka (The alternation of the superior species in the floating fishes---I. The

long-term fluctuation in the resource and the change of distribution area). (Same bulletin as in 30) (34), 21-31

47. NISHIMURA, Saburo (1958) Chubu Nihonkaisan masaba no setsuji ni tsuite (The feeding of Pneumatophorus japonicus in the middle area of the Japan Sea). Nissuiken Nenpo (Ann. Rep. Japan Fish. Res. Inst.) (4), 105-112

48. ODACHI, Kazuko (1979) Sanriku · Joban engan suiiki ni okeru okiami gyogyo ni tsuite (The krill fishery in the Sanriku and Joban coastal areas). (Same bulletin as in 18) (40), 15-25

49. ibid. (1984) Okiami gyogyo to shigen (The Krill fishery and the resource). Nihon Suisangakkai Tohoku Shibukaiho (Bull. Tohoku Branch, Japan. Soc. Sci. Fish.) (34), 38-48

50. ODACHI, Shigeru (1957) Tohoku kaiku ni okeru katakuchi-iwashi ni tsuite (Engraulis japonica in the Tohoku sea region). (Same bulletin as in 18) (9), 111-128

51. OGAWA, Yoshihiko (1979) Suisangaku ni okeru kaiyo kankyo no toraekata---1975 nen Shema eno hoi (Understanding of the ocean environment in the fishery science---a supplement to 1975 Sci. E. M. A.*---). Michurin Seibutsu-gaku Kenkyu (Michurin Biological Studies) 15 (1), 2-22

52. ibid. (1987) Tohoku kaiku ni okeru takakusei fugyo gyokyo no hendo yoshiki (The catch-fluctuation patterns of the floating fish caught abundantly in the Tohoku

* translator's note : meaning not quite clear

sea region). (Same bulletin as in 18) (49), 17-33

53. OGAWA, Yoshihiko and NAKAHARA, Tamio (1979) Fugyorui ni okeru takuetsushu no kotai---II. Fugyorui bunpuiki no kaikyo tokusei to sono hendo (The alternation of the superior species in the floating fishes---II. The hydrographic characteristics and the change in the distribution area of the floating fishes). (Same bulletin as in 30) (35), 1-13

54. OGAWA, Yoshihiko, HIRAI, Mitsuyuki and YASUDA, Ichiro (1987) Oyashio Daiichi Kannyu no hendo to sono suisan seibutsu eno eikyo (The variation of the First Oyashio Intrusion and its influence on the marine life). (Same bulletin as in 18) (49), 1-15

56. OKIYAMA, Toshio (1965) Nihonkai okiai ni okeru surumeika Todarodes pacificus (STEENSTRUP) no shokusei (The food habit of Todarodes pacificus off the Japan Sea). (Same bulletin as in 19) (14), 31-41

57. OKIZAKI, Katsumi (1985) Gyogyosha kara erareta Fukushima-Ken sokobikiami gyogyo no sogyo jittai (The actual operational condition of the trawl fishery in Fukushima Prefecture obtained from the fishermen). Showa 59 nendo Fukushima-Ken Suishi Jigyo Hokoku (The 1984 Business Rep. Fukushima Pref. Fish. Exptl. Sta.), 68-70

60. OKUTANI, Takashi (1983) Akaikaka no bunrui to seitai, (6) Surumeika aka no seitai (The classification and the ecology of Ommastrephidae, (6) The ecology of Todarodes

pacificus). Kaiyo to Seibutsu (The Ocean and Organisms) (26), 180-183

63. OMIHARA, Hiroshi (1980) Makiami gyogyo gaishi. Junenshi. p. 23 (General history of the surrounding-net fishery. The decennary history). 3-211, Tokyo, Zenkoku Makiami Gyogyo Kyokai (National Association of the Surrounding-net Fishery), 458 pp.

64. SAISHU, Kozo (1963) Kokai Higashi Shinakai ni okeru teisei gyorui no kukan senkyo kankei (The space occupational relationship among the bottom fishes in the Yellow Sea and the East China Sea), Nishisuiken Kenpo (Bull. Nishi Reg. Fish. Res. Lab.) (26), 1-164

65. SASAKI, Tomoko (1987) Sanriku engan kaiiki ni raiyu suru surumeika no gunkozo (The group structure of Todarodes pacificus migrating to the Sanriku coastal area). (Same journal as in 42) (9), 65-72

66. SADAKATA, Tsutomu (1982) 1981 nen Kushiro oki de gyokaku sareta surumeika ni tsuite (On Todarodes pacificus caught off Kushiro in 1981). Ikarui Shigen Cyo Kaikyo Kento Kaigi Gijiroku (Prodeedings of the Investigative Council on the Squid Resource and the Hydrographic Conditions for the Squid Fishery), 20-25

67. SATO, Yuji (1986) Fugyorui no suryo hendo---Tohoku kaiku o chushin ni shite---(Quantitative fluctuations in the floating fishes---mainly in the Tohoku sea region---). Kaiyo Kagaku (Ocean Science) 18 (4), 252-257

68. SATO, Yuji, IIZUKA, Kagenori and KUBOTA, Seigo (1975) Tohoku kaiku engan oyobi kinkaiiki ni bunpu suru masaba o meguru gyoshukan kankei (The relationships among the fishes in connection with Pneumatophorus japonicus distributed in the Tohoku coastal region and the adjacent regions). (Same bulletin as in 18) (35), 1-13

70. SHIBATA, Kenji (1984) Boso kaiiki ni bunpu suru surumeika no seitai ni kansuru kenkyu---I (Studies on the ecology of Todarodes pacificus distributed in the Boso sea region---I). Chibasuishi Kenpo (Bull. Chiba Pref. Fish. Exptl. Sta.) (42), 13-21

71. SHINGU, Kazuo, WARASHINA, Yukio and MATSUZAKI, Sadao (1974) Seibu Taiheiyo de haenawa ni yotte gyokaku sareru kuromaguro no bunpu (The distribution of Thunnus thynnus caught by the pole and line fishery in the western Pacific Ocean). Enyo Suikenpo (Bull. Pelagic Fish. Res. Lab.) (10), 109-140

72. SHINGU, Kazuo, MURATA, Mamoru and ISHII, Tadashi (1983) Nihon no Taiheiyo engan ni okeru surumeika no gyokaku hendo (The catch fluctuations of Todarodes pacificus in Japanese coastal waters of the Pacific Ocean). (Same bulletin as in 43) (48), 21-36

73. SUZUKI, Hirotaka (1980) Sagamiwan shubeniki ni bunpu suru surumeika no seitai ni kansuru kenkyu---II. Raiyuryo no keinen, kisetsu hendo oyobi koreto kanren suiiki no dohendo tono kankei (Studies on the ecology

of Todarodes pacificus distributed in Sagami Bay and the surrounding area---II. The annual and seasonal fluctuations in the quantity of migration and the relationship with those in the related area). Kanagawa-suishi Kenpo (Bull. Kanagawa Pref. Fish. Exptl. Sta.) (1), 15-23

76. TAKEUCHI, Hiroshi, EBE, Ken'ichi, MATSUMOTO, Yasuo and OKIZAKI, Katsumi (1985) Fukushima-Ken ni okeru sokobiki-ami gyogyo shigen no genjo to gyogyo kanri (The present condition of the resource for the trawl fishery and the fishery management in Fukushima Prefecture). Showa 59 nendo Fukushimasuishi Jigyo Hokoku (The 1984 Business Report, Fukushima Pref. Fish. Exptl. Sta.), 76-83

77. TANAKA, Shoichi (1985) Suisan shigengaku soron (An introduction to the study of fishery resources). 381 pp. Tokyo, Koseisha Koseikaku

78. Tohokuku Suisan Kenkyusho Hachinohe Shisho (Hachinohe Branch, Tohoku Regional Fisheries Research Laboratory) (1957). Surumeika chosa no aramashi (An outline of the investigation on Todarodes pacificus). Teigyo Joho (Bottom Fish Information) (12), 78-82

79. ibid. (1980) Aomori-Ken Taiheiyogawa okiai no teigyorui no shigen doko ni tsuite (The trend in the bottom-fish resource in the offshore of the Pacific Ocean of Aomori Prefecture) (Showa 27 nen-51 nen) (1952-1976). Teigyo Shigen Chosa Shiryo II (The Bottom-fish Resource

Investigation Data), 83 pp.

80. Tokaiku Suisan Kenkyusho (Tokai Regional Fisheries Research Laboratory) (1970) Joban-Surugawan no katakuchi-iwashi (Engraulis japonica in Joban-Suruga Bay). Tokaiku Choki Gyokyo Yoho (Tokai Regional Long-term Catch Forecast))20), 34-37

81. Tohoku Rekishi Shiryokan (Tohcku Historical Archives) (1984a) Sanriku engan no gyoson to gyogyo no shuzoku (Customs of the fishing villages and the fisheies of the Sanriku coast) (Jokan) (Vol. I). 260pp. Sendai-Shi, Imano Heiban Insatsu Kabushiki Kaisha

82. ibid. (1984b) ibid. (Gekan) (Vol. II). 280 pp. ibid.

87. YAMAGUCHI, Yuichiro (1979). Tsuri no gyokaku sentakusei (The catch selectivity of angling). Nippon Suisan Gakkaihen (Japanese Society of Scientific Fisheries edit.), Gyogu no gyokaku sentakusei (The catch selectivity of fishing gears), 82-96. Tokyo, Koseisha Koseikaku

88. YAMAKAWA, Fumio (1977) Nihonkai okiai suiiki ni okeru surumeika no i naiyobutsu chosa kara mita shokusei (The food habit observed from the investigation of the stomach contents of Todarodes pacificus in the offshore area in the Japan Sea). Nihonkai Surumeika Kyodo Chosa Hokokushu (Reports of the Joint Investigation on Todarodes pacificus in the Japan Sea) (Nissuikenhen) (Japan Fish. Res. Inst. edit.), 257-262

89. YAMANAKA, Hitoshi (1982) Taiheiyo ni okeru kuromaguro

no seitai to shigen (The ecology and the resource of Thunnus thynnus in the Pacific Ocean). Nihon Suisan Shigen Hogo Kyokai Suisan Kenkyu Sosho (The Fisheries Study Series, Japan Fisheries Resource Protection Association) (34), 140 pp. Tokyo, Ishizaki Shoten

90. YAMASHITA, Hideo (1956) Kyushu nishi kaigan ni okeru iwashi, aji, sabarui no shiryo no sogo kankei ni tsuite (The mutual relationships of the feed of sardines, horse mackerels and mackerels in the west coast of Kyushu). (Same bulletin as in 64) (11), 46-53

92. YASUI, Tatsuo (1974) Ika shigen o meguru shomondai (Various problems surrounding the squid resource). Kita Nihon Gyogyo (The Northern Japanese Fisheries) (6), 13-22

93. ibid. (1975) Nihon hokubu kaiiki no surumeika fuyu umaregun no shigenryo no shocho to shugyojo no hensen (The increase and decrease in the quantity of resource of the winter group of Todarodes pacificus in the northern Japan sea area and the change in the major fishing grounds). Sekai no Ika·Tako Shigen no Kaihatsu to sono Riyo (The Development and Utilization of the World Resources of Squids and Octopuses), Kaiyo Suisan Shigen Kaihatsu Senta Shiryo (The Ocean Fisheries Resources Development Center Data) 5, 97-100

94. YASUI, Tatsuo, KUBOTA, Seigo, HASHIBA, Toshio, SAITO, Shigeo, MINATO, Eiichi and MATSUI, Takeshi (1972a)

Tohoku・Hokkaido Taiheiyogawa kaiiki ni okeru surumeika no bunpu to kaiyu (The distribution and the migration of Todarodes pacificus in the Tohoku and Hokkaido area of the Pacific Ocean). (Same report as in 7) (57), 68-94 p. 24

95. ibid. Tohoku・Hokkaido Taiheiyogawa kaiiki ni okeru surumeika no keitogun (The genealogical group of Todarodes pacificus in the Tohoku and Hokkaido area of the Pacific Ocean). ibid. (57), 181-191

96. YOKOTA, Takio, TOYAMA, Masahiro, KANAI, Fukuko and NOMURA, Seiji (1961) Gyorui no shokusei no kenkyu (Studies on the food habits of the fishes). Nankaisuiken Kenpo (Bull. Nankai Reg. Fish. Res. Lab.) (14), 1-234

Bibliography文　献

1 阿部宗明 (1985) 1984年夏季における東北海区沖合

から岩手県沿岸へのスルメイカの加入について．昭和59年度イカ類資源・漁海況検討会議研究報告（北水研編），45-54

2 阿部 道（1981） スルメイカの胃内容物より見た食性についての初歩的考察．安東守敦編，阿部道の足跡，遺稿と追悼集，5-16．塩釜市，工陽社，108 pp.

3 新谷久男（1967） スルメイカの資源．日本水産資源保護協会水産研究叢書(16)，60 pp. 東京，石崎書店

4 新谷久男（1974） いか釣漁業資源の管理に関する問題点．漁業資源研究会議報（16），71-78

5 ARAYA, H. (1976) Migration and fishing ground of winter subpopulation of the squid, *Todarodes pacificus* STEENSTRUP, in the northern waters of Japan. *Bull. Hokkaido Reg. Fish. Res. Lab.* (41), 119-129

6 新谷久男（1985） スルメイカ漁業の変遷と資源の動向．昭和59年度イカ類資源・漁海況検討会議研究報告（北水研編），1-6

7 新谷久男・石井 正（1972） 北海道周辺海域におけるスルメイカの系統群．農林水産技術会議研究成果(57)，192-205

8 新谷久男・中道克夫（1962） 1959, '60年に調査されたスルメイカの胃内容物について．北水試月報 19 (4)，8-14

9 CHIKUNI, S. (1985) The fish resources of the northwest Pacific. *FAO Fish. Tech. Pap.* (266), 190 pp.

10 土井長之（1962） 日本近海魚類の魚種間相互関係の解析についての研究．東海水研報（32），49-121

11 土井長之・川上武彦（1979） 日本近海産スルメイカの生物生産と漁業の管理．東海水研報（99），65-83

12 ELTON, C.S. (1933) *The Ecology of Animals*. Methuen & Co. Ltd. 川那部浩哉・桜井宏明・井原敏明・堀 道男・谷田一三訳（1978） 動物の生態，293+XX pp. 東京，思索社

13 ELTON, C.S. (1958) *The Ecology of Invasion by Animals and Plants*. Methuen & Co. Ltd. 川那部浩哉・大沢秀行・安部琢哉訳（1971） 侵略の生態学，223+XV pp. 東京，思索社

14 GORDON, H.S. (1953) An economic approach to the optimum utilization of fishery resources. *J. Fish. Res. Bd. Canada* 10(7), 442-457

15 長谷川 彰（1985） MEYの事例解析―日本近海スルメイカ資源に対する適正管理への接近―．漁業管理，新水産学全集 35，103-130．東京，恒星社厚生閣，236 pp.

16 HATANAKA, M., SEKIDO, K., TAKAHASHI, M. and ICHIMURA, T. (1957) Growth and food consumption in young mackerel, *Pneumatophorus japonicus*. *Tohoku Jour. Agr. Res.* 7(1), 351-358

17 橋本良平（1980） 東北海区の沖合底曳網の漁法別漁獲性能について．昭和54年度漁業資源研究会議北日本底魚部会会議報告，84-92

18 飯塚景記（1987） 東北北部海域におけるマサバ未成魚の生態的地位．東北水研研報（49），35-59

19 伊東祐方（1961） 日本近海におけるマイワシの漁業生物学的研究．日水研報告（9），1-227

20 岩手県（1984） 岩手県漁業史，974+(195)pp. 盛岡市，熊谷印刷

21 岩手県水産試験場（1960） 岩手県の漁業の実相．岩手県水産試験場業績（創立50周年記念），445 pp. 釜石市，東海印刷所

22 上村清幸（1972） 房総近海のスルメイカ―II. 関東近海のスルメイカに関する研究報告集（東海水研資源部編），1-9

23 金田禎之（1979） 八戸沖漁場における宿命のいか・さば紛争．漁業紛争の戦後史，281-348，東京，成山堂書店，371+VII pp.

24 KAWAI, H. (1972) Hydrography of the Kuroshio Extension. In: *Kuroshio—Its Physical Aspects* (ed. STOMMEL, H. and YOSHIDA, K.), 235-352. Tokyo, University of Tokyo Press, 518 pp.

25 川合英夫（1975） 海洋環境の特性．平野敏行編，海洋生物資源環境，海洋学講座 15，11-20，東京，東京大学出版会，241 pp.

26 KAWAI, H. and SAITOH, S. (1986) Secondary fronts, warm tongues and warm streamers of Kuroshio Extension system. *Deep-Sea Res.* 33 (11/12), 1487-1507

27 KAWAMURA, H., MIZUNO, K. and TOBA, Y. (1986) Formation process of a warm-core ring in the Kuroshio-Oyasio frontal zone—December 1981-October 1982. *Deep-Sea Res.* 33(11/12), 1617-1640

28 川崎 健（1972） 本邦太平洋側におけるスルメイカの資源構造．農林水産技術会議研究成果(57)，168-180

29 川崎 健・八百正和・安東守敦・永雷 準・浅野政宏（1962） 東北海区に分布する表層性魚食性魚類群集体の構造とその変動機構について．東北水研研報（22），1-44

30 北川大二・山下 洋（1986） 岩手県沿岸域におけるイカナゴ仔魚の出現，分布，移動拡散．水産海洋研究会報 50(3)，205-213

31 児玉純一（1988） 宮城県沿岸に生息するイカナゴの系群構造と資源状態．宮城水試研報（10），1-41

32 小牧勇蔵（1974a） 日本沿岸のオキアミ漁業とその利用．水産海洋研究会報（24），49-52

33 小牧勇蔵（1974b） オキアミ，特に日本近海におけるツノナシオキアミ（*Euphausia pacifica* H. JHANSEN）について．*JAMARC* (5)，2-9

34 KUBODERA. T.，PEARCY. W.G.，MURAKAMI. K.，KOBAYASHI. T.，NAKATA. J. and MISHIMA. S.（1983） Distribution and abundance of squids caught in surface gillnets in the subarctic Pacific, 1977-1981. *Mem. Fac. Fish. Hokkaido Univ.* 30(1/2)，1-49

35 松井 勇・川崎 健（1971） 常磐沖におけるスルメイカの資源構造について．東海水研報（64），57-69

36 松田皇二・花岡藤雄・古藤 力・浅見忠彦・浜部基次（1972） 本邦南西海域におけるスルメイカの再生産機構とその変動要因．農林水産技術会議研究成果（57），10-30

37 三河正男（1960） 東北海域底魚資源，青山恒雄編，底魚資源，新水産学全集 10，191-204．東京，恒星社厚生閣，360 pp.

38 水野恵介（1984） 東北海区の海況変動について．東北水研研報（46），61-80

39 MIZUNO. K. and WHITE. W.B.（1983） Annual and interannual variability in the Kuroshio Current System. *J. Phys. Oceanogr.* 13，1847-1867

40 村上幸一（1972） スルメイカ資源研究の現状と問題点．昭和46年度漁業資源部門担当者会議議事録（北海道立釧路水試），1-18

41 村上幸一（1976） 北西太平洋におけるイカ類の分布について．北水試月報 33(1)，2-18

42 村田 守・新谷久男（1977） スルメイカ冬生まれ群資源の現状と問題点．日本海ブロック試験研究集録（1），1-13

43 村田 守・石井 正・新谷久男（1976） 北海道・三陸太平洋海域における外洋性イカ類（アカイカ，ソメイカ，タコイカ，スルメイカ）の分布について．北水研報告（41），1-29

44 内藤敬治・村上幸一・中山信之・小林 晋・小笠原博六（1976） 北西太平洋におけるイカ類の分布と回遊．水産海洋研究会報（29），53-56

45 内藤敬治・村上幸一・小林 晋・中山信之・小笠原博六（1977） 北西太平洋亜寒帯水域における外洋性イカ類の分布と回遊．北大水産北洋研究施設(特別号)，321-337

46 中原民男・小川嘉彦（1979） 浮魚類における卓越種の交替—I. 資源の長期変動と分布域の変化．水産海洋研究会報（34），21-31

47 西村三郎（1958） 中部日本海産マサバの鱗鑑について．日本海年報（4），106-112

48 小達和子（1979） 三陸・常磐沿岸水域におけるオキアミ漁場について．東北水研研報（40），15-25

49 小達和子（1984） オキアミ漁場と資源．日本水産学会東北支部会報（34），38-48

50 小倉 通（1957） 東北海区におけるカタクチイワシに就いて．東北水研研報（9），111-128

51 小川嘉彦（1979） 水産学における海洋環境の捉え方—1975年シェマへの補遺—．ミチューリン生物学研究 15(1)，2-22

52 小川嘉彦（1987） 東北海区における多種性浮魚漁況の変動様式．東北水研研報（49），17-33

53 小川嘉彦・中原民男（1979） 浮魚類における卓越種の交替—II. 浮魚類分布域の海況特性とその変動．水産海洋研究会報（35），1-13

54 小川嘉彦・平井光行・安田一郎（1987） 親潮第一貫入の変動とその水産生物への影響．東北水研研報（49），1-15

55 OKATA. A.（1975） Ecological studies on the biological production of young amberfish community in the Sendai Bay—I. Food chains in the amberfish community. *Bull. Japan. Soc. Sci. Fish.* 41(12)，1247-1262

56 神山宗雄（1965） 日本海神合におけるスルメイカ *Todarodes pacificus*（STEENSTRUP）の食性．日水研報告（14），31-41

57 神崎克己（1985） 漁業者から得られた福島県底曳網漁業の操業実態．昭和59年度福島水試事業報告，68-70.

58 OKUTANI. T.（1962） Diet of the common squid *Ommastrephes sloani pacificus* landed around Itō Port, Shizuoka Prefecture. *Bull. Tokai Reg. Fish. Res. Lab.* (32)，41-47

59 OKUTANI. T.（1969） Studies on early life history of decapodan mollusca IV. Squid larvae collected by oblique hauls of larvae net from the Paccific coast of eastern Honshu, during the winter seasons, 1965-1968. *Bull. Tokai Reg. Fish. Res. Lab.* (58)，83-96

60 奥谷喬司（1983） アカイカ科の分類と生態．(6) スルメイカ亜科の生態．海洋と生物（26），180-183

61 OKUTANI. T. and WATANABE. T.（1983） Stock Assessment by Larval Surveys of the Winter Population of *Todarodes pacificus* STEENSTRUP (Cephalopoda : Ommastrephidae), with a Review of Early Works. *Biological Oceanography* 2(2/3/4)，401-431

62 OSAKO. M. and MURATA. M.（1983） Stock assessment of cephalopod resources in the northwestern Pacific. *FAO Fish. Tech. Pap.*

(231), 55-144

大藤康 宏 (1980) まき網漁業概史. 給年史, 3-211, 東京, 全国まき網漁業協会, 458 pp.

桑雷光三 (1963) 黄海・東シナ海における底魚類の空間占拠関係. 西水研研報 (26), 1-164

佐々本知子 (1987) 三陸沿岸海域に来遊するスルメイカの群構造. 日本海ブロック試験研究集報(9), 65-72

貞方 勉 (1982) 1981年調査沖で漁獲されたスルメイカについて. イカ類資源・漁海況検討会議報告, 20-25

佐藤裕二 (1986) 浮魚類の数量変動—東北海区を中心にして—. 海洋科学 18(4), 252-257

佐藤裕二・飯塚景記・久保田清吾 (1975) 東北海区沿岸および近海域に分布するマサバをめぐる魚種間関係. 東北水研研報 (35), 1-13

SCHAFFER. B. M. (1957) Some considerations of population dynamics and economics in relation to the management of the commercial marine fisheries. *J. Fish. Res. Bd. Canada* 14(5), 669-681

芝田健二 (1984) 房総海域に分布するスルメイカの生態に関する研究—I. 千葉水試研報 (42), 13-21

新宮千臣・蘭科侑生・松崎憲雄 (1974) 西部太平洋ではえなわによって漁獲されるクロマグロの分布. 遠洋水研報 (10), 109-140

新宮千臣・村田 守・石井 正 (1983) 日本の太平洋沿岸におけるスルメイカの漁獲変動. 北水研報告 (48), 21-36

鈴木弘敏 (1980) 相模湾周辺域に分布するスルメイカの生態に関する研究—II. 来遊量の経年, 季節変動およびこれと関連水域の同変動との関係. 神奈川水試研報 (1), 15-23

SUZUKI. T. (1963) Studies on the relationship between current boundary zones in waters to the southeast of Hokkaido and migration of the squid, *Ommastrephes sloani pacificus* (STEENSTRUP). *Mem. Fac. Fish. Hokkaido Univ.* 2(2), 75-153

TAKANO. H. (1954) The food of the mackerel taken near Oshima Island in 1953. *Bull. Japan. Soc. Sci. Fish.* 20(8), 694-697

竹内 啓・江部健一・松本育夫・沖崎克己 (1985) 福島県における底曳網漁業資源の現状と漁業管理. 昭和59年度福島水試事業報告, 76-83

田中昌一 (1965) 水産資源学総論, 381 pp. 東京, 恒星社厚生閣

東北区水産研究所八戸支所 (1957) スルメイカ調査のあらまし. 底魚時報 (12), 78-82

東北区水産研究所八戸支所 (1980) 青森県太平洋側沖合の底魚類の資源動向について(昭和27年～51年). 底魚資源調査資料 II, 83 pp.

東海区水産研究所 (1970) 常磐～駿河湾のカタクチイワシ. 東海区長期漁況予報 (20), 34-37

東北歴史資料館 (1984a) 三陸沿岸の漁村と漁業の習俗 (上巻), 260 pp. 仙台市, 今野平版印刷株式会社

東北歴史資料館 (1984b) 三陸沿岸の漁村と漁業習俗 (下巻), 280 pp. 仙台市, 今野平版印刷株式会社

TOMOSADA. A. (1978) A large warm eddy detached from the Kuroshio east of Japan. *Bull. Tohai Reg. Fish. Res. Lab.* (94), 59-103

TOMOSADA. A. (1986) Generation and decay of Kuroshio warm-core rings. *Deep-Sea Res.* 33 (11/12), 1475-1486

UDA. M. (1957) A consideration on the long years trend of the fisheries fluctuation in relation to sea condition. *Bull. Japan. Soc. Sci. Fish.* 23 (7/8), 368-372

VOLTERRA. V. (1928) Variations and fluctuations of the number of individuals in animal species living together. (translated into English by M.E. Wolls). *J. Cons. int. Explor. Mer.* (3), 1-51

山口裕一郎 (1979) 釣りの漁獲選択性. 日本水産学会編, 漁具の漁獲選択性, 82-96, 東京, 恒星社厚生閣, 127 pp.

山川文男 (1977) 日本海沖合水域におけるスルメイカの胃内容物調査からみた食性. 日本海スルメイカ共同調査報告集 (日水研編), 257-262

山中 一 (1982) 太平洋におけるクロマグロの生態と資源. 日本水産資源保護協会水産研究叢書(34), 140 pp. 東京, 石崎書店

山下秀夫 (1956) 九州西部岸におけるイワシ, アジ, サバ類の餌料の相互関係について. 西水研研報 (11), 46-53

YASUDA. F. (1960) The types of food habits assured by stomach contents examination. *Bull. Japan. Soc. Sci. Fish.* 26(7), 653-662

安井達夫 (1974) イカ資源をめぐる諸問題. 北日本漁業 (6), 13-22

安井達夫 (1975) 日本北部海域のスルメイカ冬生れ群の資源量の消長と主漁場の変遷. 世界のイカ・タコ資源の開発とその利用. 海洋水産資源開発センター資料 5, 97-100

安井達夫・久保田清吾・横場敏雄・斉藤宜男・浜 栄一・鉄井 勇 (1972a) 東北・北海道太平洋側海

域におけるスルメイカの分布と回遊．農林水産技術会議研究成果（57），68-94

95 安井達夫・久保田清吾・福場敏夫・斉藤重男・裏　栄一・松井　勇（1972b）東北・北海道太平洋側海域におけるスルメイカの系統群．農林水産技術会議研究成果（57），181-191

96 横田滝雄・道山正弘・金井富久子・野村里二（1961）魚類の食性の研究．南海水研研報（14），1-234

東北区水産研究所業績第 418 号
（1987 年 12 月 28 日受理）

Address: OGAWA, Tohoku Regional Fisheries Research Laboratory, 3-27-5 Shinhama, Shiogama, Miyagi 985, Japan（東北区水産研究所）
SASAKI, Iwate Prefectural Fisheries Experimental Station, 1-4-21 Shinhama, Kamaishi, Iwate 026, Japan（岩手県水産試験場）

UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement